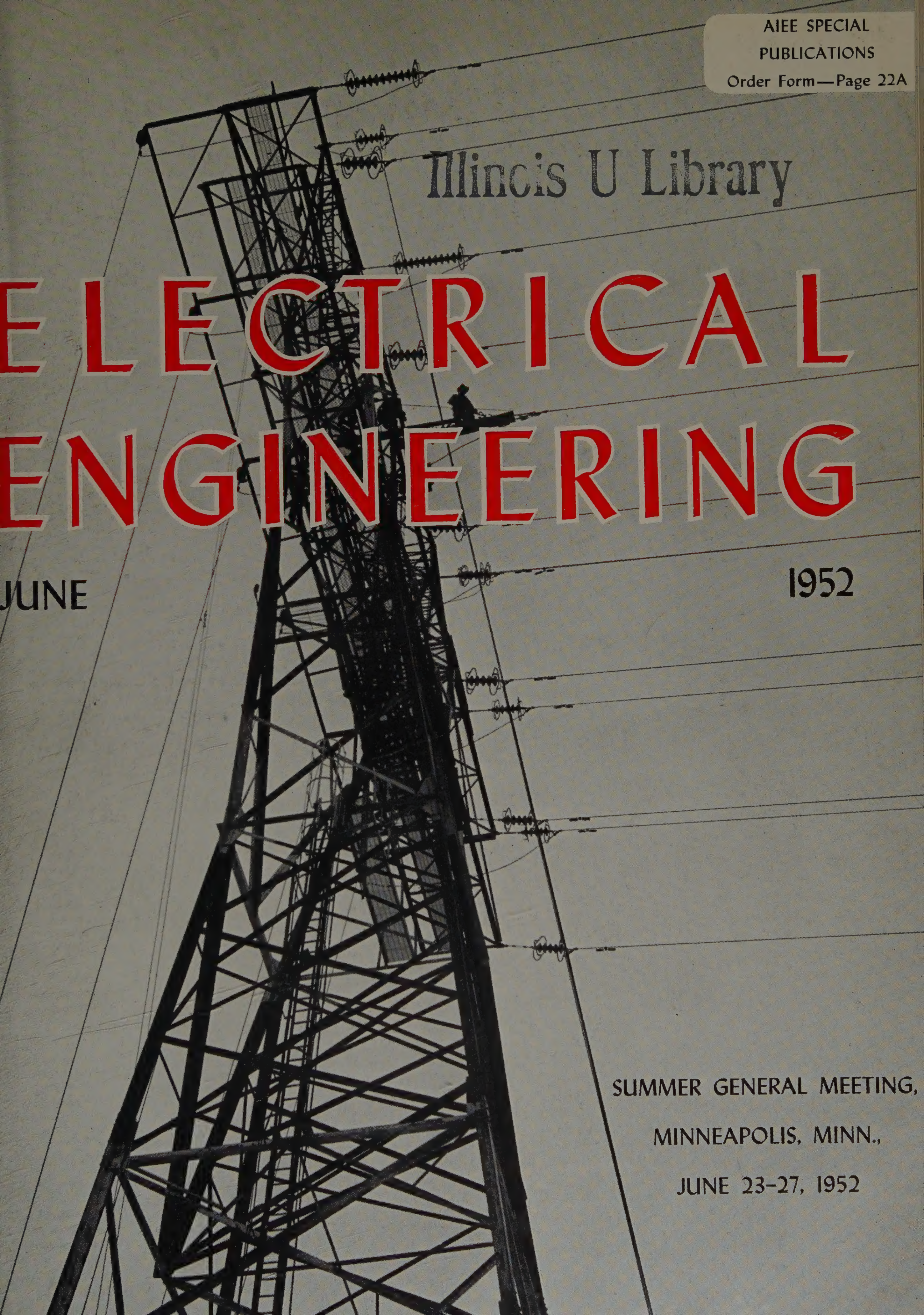
ELECTRICAL ENGINEERING



JUNE 1952

SUMMER GENERAL MEETING,
MINNEAPOLIS, MINN.,
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ELECTRICAL ENGINEERING

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JUNE
1952

The Cover: A circuit, one of four originally installed for 22-kv operations, is here being reinsulated for 115-kv operation on one of the two towers of the Hartford Electric Light Company transmission span across the Connecticut River. Total height of the tower is 175 feet from the foundation to the ground wire attachment. The base size is 35 feet square, with an elevation of 30 feet. Tower's total weight is 64 tons. River clearance is 120 feet above elevation 0.0.

TECHNICAL PAPER DIGESTS

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HIGHLIGHTS........

Engineering Education. Why has engineering education in the United States, and, consequently, American industry, advanced so much more rapidly than that in Europe? AIEE President McMillan considers the question in an article which originally was presented as an address before the South West District Meeting in St. Louis (*pages 487–91*).

Vision in Power. The increasing use of electric power brings with it many problems which must be considered in the development of future power systems. The author, Philip Sporn, points out the need for vision and imagination if the industry is to plan for sound and efficient growth (*pages 491–4*).

European Railroad Electrification. Electrification of European railroads is quite different from that of American railroads. The author compares the several systems in use in Europe today, and considers the prospects for their utilization in the United States (*pages 497–501*).

European Electrical Safety Regulations. This brief survey of the safety requirements covering lighting, appliance, and small commercial and industrial uses of power in various European countries, discusses standardization trends and safety tests applied to electric equipment, as well as where to obtain further information (*pages 527–8*).

Temperature Differentials in Single-End Ventilated Integral-Horsepower Motors. The results of 92 commercial temperature tests on single-end ventilated open-type motors showed that for all practical purposes the temperature rise by resistance is the same as the temperature rise by surface thermocouple. The author recommends a change in testing procedure (*pages 535–6*).

News Index

Loss Mechanisms in Gas Discharges. The electron and ion loss mechanisms are often the controlling features of a gas discharge tube. This article points out the physical phenomena which are mainly responsible for the loss of charged particles (*pages 501–03*).

Braking Devices for 400-Cycle Motors. The many kinds of remotely and automatically controlled positioning devices used in modern airplanes require stopping devices for the motors which operate them. The salient features of the more commonly used braking devices are compared in this survey (*pages 506–11*).

Specific Objectives of Electrical Engineering Curricula. The author reviews some of the strongest criticisms of engineering curricula. He shows what has been done to correct these faults and gives an outline of future plans designed to improve engineering education (*pages 514–18*).

Dynamic Hysteresis Loop Measuring Equipment. The dynamic hysteresis loop of the magnetic material used in a magnetic amplifier plays an important role in the over-all characteristics of such a device. Measuring this characteristic curve is simplified by use of the equipment described (*pages 518–21*).

Dynamometer for Testing Small Motors. Because of the small available torque and the loading effect of most measuring devices, the testing of small motors is generally difficult. The instrument described in this article overcomes these difficulties and is capable of precise measurement of small motor characteristics (*pages 549–51*).

New Trolley Coach Motor. To meet the service requirements of the modern trolley coach, a new series-type motor has been developed. It combines the good accelerating performance of the series motor and also has a smooth, notchless, and almost constant dynamic braking effort. The latter is achieved by a shunt field winding used with a differential control circuit (*pages 523–6*).

Magnetic Structure of Alnico 5. This is one of the more important commercial permanent magnet alloys, if not the most important, and it is also one of the most interesting from a scientific point of view. Investigations are still being conducted on this alloy and the findings of two phases of these investigations are presented (*pages 530–4*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Affiliates, Associate Members, Members, and Fellows.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Mar '51, p. 35A	Winter General
July '51, p. 23A	Southern District North Eastern District Great Lakes District Summer General
Nov '51, p. 37A	Pacific General Fall General
May '52, p. 37A	North Eastern District South West District

A New Electric Locomotive. The task of designing a new electric freight locomotive for the Pennsylvania Railroad is described. The advantages of advanced design were combined with the benefits of repetitive manufacture to produce a highly satisfactory unit (*pages 537–43*).

Fault Characteristics of Aircraft Electric Systems. The possibility of installing a system to assure the operation of certain equipment which could permit the destruction of the aircraft is discussed. Recommendations to prevent such an occurrence are presented (*pages 543–7*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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Our Heritage From Engineering Education

F. O. McMILLAN
PRESIDENT AIEE

ONE OF THE MOST important factors in developing and sustaining the present industrial status of the United States is engineering education. To appreciate the present value of engineering education in the United States it is desirable to examine the history of engineering and engineering education in Europe, particularly in France, Germany, and England, and in the United States.

Engineering gradually evolved through antiquity and the Renaissance. There is no specific time at which engineering can be said to have had its beginning. The early builders were, generally speaking, both architects and engineers.

American methods of engineering education are, in large part, responsible for our country's industrial status in the world today. AIEE President McMillan here compares the history of technical education in Europe and the United States.

FRANCE

A Royal Corps for Bridges and Highways existed in France during the reign of Charles V (1364–1380). Louis XIV (1642–1715) commissioned his favorite architect, Mansart, to build a stone bridge at Moulins on the Allier. This bridge soon collapsed due to the erosion of the stream, showing that while Mansart was a master of masonry construction, he knew little about hydraulics and the erosive action of streams. The engineers of the period let it be known "that they had at their command an art of construction, applicable to great public works, more learned and more varied in its resources, looking to solidity rather than monumental decoration."

While striving to rehabilitate the economic structure of France by improving transportation, Louis XV (1715–1754) planned a large network of national highways. In 1747 Perronet was summoned to Paris to become chief engineer of bridges and highways and was charged "with the direction and supervision of surveyors and designers of plans and maps of the roads and highways of the realm and all those who are appointed and nominated to said work; and to instruct the said designers in the sciences and practices needful to fulfilling with competency the different occupations relating to the said bridges and highways."

Previously, engineers had prepared for their work by unorganized studies in isolated locations which afforded little or no contact with other engineers for the exchange of ideas and professional improvement. As a result, Perronet found there were no uniform standards or practices, either in engineering work or construction. Therefore, on December 11, 1747, he directed:

"That these employees will be divided into three classes: the first composed of under-inspectors or under-engineers; the second of employees called élevés; and the third of young men of less education who are admitted to work in the office as auxiliaries.

"That during the summer, the employees are to be distributed among the principal works in progress, to execute maps and plans."

Perronet, therefore, may be called the father of modern civil engineering and of engineering education. This school began to function in 1747 but the name École des Ponts et Chaussées was not officially bestowed nor the instruction legally regularized until 1775. In 1799 the plan of "mutual instruction" was discontinued. In other respects the school has retained most of its original characteristics, including the 3-year program, and has remained under the control of the official Corps des Ponts et Chaussées down to the present time.

Since the École des Ponts et Chaussées was exclusively under the control of, and only available for, the training of personnel for the Corps of Bridges and Highways, another school, the École des Mines, operated on a similar pattern, was established to train engineers for the mining and mineral industries. Other schools were founded to supply the technical services of industry and the State. As a source from which these specialized schools could recruit their students a preparatory institution, the École Polytechnique, was established in 1795.

GERMANY

In Germany technical education had a trying and difficult beginning but recovered rather quickly and was established entirely independent of the existing universities. Efforts first were made to have lectures in applied mathematics and related subjects given a recognized place in the curricula of the leading universities. When the ruling academic party clearly understood that it was the intention to make some practical use of the sciences they refused to admit the applied sciences because they were wholly alien to their cherished ideals and tradi-

Full text of an address presented at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952.

F. O. McMillan is Head of the Department of Electrical Engineering, Oregon State College, Corvallis, Oreg.

tions of disinterested learning. This action caused a sharp cleavage between academic and technical education. The secondary schools or gymnasiums stood with the universities, hence the early technical schools were forced to superimpose their programs on the volkschulen of the common people.

The low level of preparation attained in the volkschulen reduced the early technical schools to essentially trade schools. To overcome this situation two types of schools were developed together; one to provide the needed preparatory secondary education, the oberrealschulen, and the other the technical high school, technische hockschulen, to carry on the technical education. The good reputation of Germany in the field of technical education and her industrial development was due very largely to the concurrent development of these two complementary schools. In commenting on the development of technical education in Germany, Dr. W. E. Wickenden says: "No historical situation shows more clearly the intimate dependence of higher technical education on a sound and sympathetic scheme of secondary education, unless it is the retardation of half a century which resulted in Great Britain from the lack of such an underpinning."

A technical school, the Royal Bergakademie, was founded at Freiberg for teaching mining and metallurgy as early as 1765. Others followed and technical education in Germany evolved through three distinct periods: a trade school period from 1799 to 1835; a period of transition from trade schools to polytechnics of wide scope and professional rank 1835 to 1875; and a period of development to the university plane from 1875 to 1900.

ENGLAND

In England, chairs of civil engineering were established in the University of London and Kings' College in or about 1840, but there were a number of factors that seriously interfered with the development of engineering education until about 1900. In that year there were only 345 third-year and 52 fourth-year students of engineering in all of Great Britain. Some of the interfering factors were

1. The open gulf between the universities and industry.
2. The notable inventions of the times were the contributions of workingmen such as Newcomen an ironmonger, Watt an instrument maker, and Stephenson a fireman, trained by apprenticeship and self-taught in the rudiments of science, therefore, engineering education did not appear necessary or desirable.
3. The practical industrialists were skeptical of the value of applying what they considered remote and abstract science in industry.
4. The practicing civil engineers were trained in the old system of indenture and both they and their society, The Institution of Civil Engineers, founded in 1818, recognized pupilage as the proper form of professional training. In fact, the original bylaws of the Institution prescribed that a member "shall have been regularly educated as a Civil Engineer, according to the usual routine of pupilage."
5. Secondary education was limited to a few private schools largely devoted to the preparation of the leisured classes for matriculation in the universities, and the universities did not offer engineering.
6. Engineering was not held in high regard as a profession and hence was not attractive to young men of brilliance and promise.

Prince Albert was elected Chancellor of Cambridge University in 1847. In 1848 some graduates and former members of Cambridge University presented a memorial to Prime Minister Russell, begging for a Royal Commission of Enquiry on the grounds that the university was not advancing the interest of useful learning and that changes were necessary in order to increase its efficiency. The Royal Commission was appointed in 1850 and 8 years later the statutes of Queen Elizabeth were replaced.

The moral and natural sciences were dignified and raised to tripos* status by Prince Albert and Cavendish Laboratory with its brilliant contributions to science came from this act.

Great Britain, because of her water isolation from continental Europe, was spared much of the strife and wars of the early 19th century. This period of peace provided an opportunity to develop very rapidly industrially and enjoy a ready market for her manufactured goods. However, the London International Exhibition of 1851 revealed that her continental rivals, France and Germany, had made startling industrial progress which was attributed to their more effective use of scientific research and education. This discovery, plus some economic depressions that occurred from time to time and were attributed to the same causes, led to the turn of the tide in favor of university schools of engineering beginning about 1880.

THE UNITED STATES

In the United States there is some controversy regarding the educational institution that first offered engineering. It is well established that a professorship in engineering was included in the faculty of West Point when it was reorganized in 1812. Also, when founded in 1802 the military academy was a school for engineers and artillerists. Alden Partridge, who was graduated from West Point in 1806, was Professor of Engineering there from 1813 to 1815 and Superintendent from 1815 to 1817.

In 1819 Captain Alden Partridge founded the American Literary, Scientific and Military Academy (now Norwich University) in Norwich, Vt. This academy, among a number of other courses, offered a course in civil engineering as shown by a prospectus printed in 1821. The records are reported to show that within the period from 1819 to 1825 some 20 young men, who later became well-known civil engineers, received their early instruction in civil engineering at this academy.

On November 5, 1824, Stephen Van Rensselaer announced that he was establishing a school in Troy, N. Y., to train students in "the application of science to the

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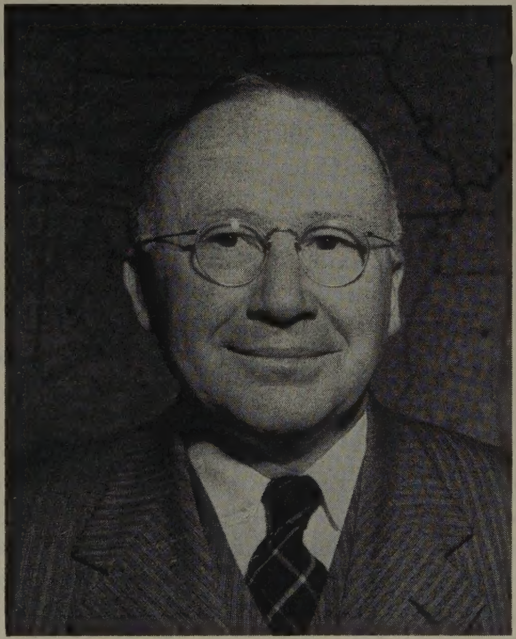
* Honor examinations at Cambridge University, instituted in the first half of the 18th century for mathematics and later extended to other subjects.

common purpose of life." To direct this school he chose Amos Eaton, who had proposed and organized the venture. Amos Eaton, Esq., of Troy was Professor of Chemistry and Natural Philosophy and Lecturer on Geology, Land Surveying, and so forth; in fact, he was the entire staff. In the period from 1824 to 1834 Rensselaer School was housed in six rooms of Professor Eaton's place of residence, which formerly had been a bank. These rooms provided a classroom, a library, three laboratories, and a museum of specimens.

Eaton's first instructions were: "These are not to be taught by seeing experiments and hearing lectures according to usual methods but they are to lecture and experiment by turns under the immediate direction of a professor or a competent assistant."

Between 1826 and 1834 Rensselaer conferred the traditional academic degrees of bachelor of arts and master of arts and in 1835 it granted its first degrees in science and in civil engineering.

For our purpose it does not matter which institution was the first to offer engineering courses or degrees, but it is important that concurrently with the industrial development of the United States the necessary educational programs to provide the technical knowledge were evolving and developing.



F. O. McMillan

During the evolution and development of our engineering education, the engineers, educators, and industrialists of this country, through The American Society for Engineering Education, had the foresight and courage to make one of the most comprehensive investigations of our engineering education that ever has been made in any field of education. This survey was directed by the late Dr. William E. Wickenden, a past president of the AIEE. From this investigation, conducted from 1923 to 1929, many benefits were derived but probably the most notable was the formation of the Engineers Council for Professional Development (ECPD). Among other outstanding developments the ECPD organized and put in operation the present system of accrediting engineering curricula in the United States. This is not a program for standardizing engineering education, but simply a means of determining whether a particular engineering curriculum will provide a sound engineering education. There is no intent or desire to force engineering education into a particular mold or pattern, but rather to give the maximum freedom for the exercise of originality and improvement.

In 1950 there were 190 schools in the United States offering undergraduate work in engineering and of these 142 had curricula accredited by the ECPD. The undergraduate enrollment in the ECPD accredited institutions was 88.5 per cent of the total enrollment and the first degree graduates from the accredited schools represented 91.2 per cent of the 52,732 engineering graduates for the academic year 1949–50.

THE VALUE OF ENGINEERING EDUCATION

The layman and even the engineer seldom, if ever, stop to consider how well our educational program in science and engineering has served our needs, or to speculate what our present physical and economic condition would be if it had failed. I believe that our spiritual status also would be at a much lower level if we had failed to develop an adequate program of technical education to build and maintain the facilities for a high standard of living. We deplore the prostitution of scientific and engineering developments to the degradation and destruction of mankind; however, if we critically examine our situation we find that these developments are contributing much to his uplift and betterment.

In the 25-year period from 1925 to 1950 actuarial data show that the average life expectancy of a man in the United States increased 8 years, or 14 per cent. Ordinarily we think of the increase in life span as due to the contributions of medical science and surgery. Important as the medical and surgical contributions have been, there are many other factors contributing to this increased life span and several of these are directly attributable to the work of engineers and engineering. To enumerate a few of the engineering factors, we may mention water supply, sanitation, heating, ventilating, lighting, refrigeration, transportation, and the mechanization and application of power in agriculture and industry.

Typhoid epidemics are practically unheard of today largely because the engineer has built and maintained pure water supply systems. Sanitary systems localize and destroy contamination. Fast transportation and refrigeration make it possible to have fresh fruits, vegetables, and other foods during all seasons of the year and they contribute much to present-day healthful diets. The mechanization and application of power in agriculture and industry has increased the production of food and manufactured goods thereby making it possible to feed, clothe, and house our population better. These improved conditions result in better health and a longer life span.

The United States had 40,709,000 telephones on January 1, 1950. This was 58 per cent of the telephones in the

world. In 1950 France had 5.6, the United Kingdom 10.2, Switzerland 18.2, Sweden 22.8, and the United States 27.1 telephones per 100 population. During 1950 the number of radio and television sets in use in the United States was 114 million, or 53 per cent of the world total.

The production of electric energy in the United States was 388 billion kilowatt-hours during 1950 or 2,580 kilowatt-hours per capita. This is from two to five times the electric energy production per capita in most of the European nations.

The steel production in the United States during 1950 was 96.8 million short tons or 1,286 pounds per capita. In 1950 the aluminum production in the United States was 1.4 billion pounds or 9.3 pounds per capita.

These few examples of use and production will serve to remind us the extent to which our engineering, technology, and industry have been developed.

I do not wish to imply that the present industrial prestige of the United States is due solely to our educational program in the applied sciences and engineering. Personal initiative, enterprise, and a willingness to work hard have played a great part, extensive natural resources have made and are continuing to make a large contribution, but all of these would have been, and in the future will be, of no avail without the technical knowledge to direct and utilize them to the greatest advantage. The expansion of scientific knowledge and the growing complexity of our civilization makes education and training in science, engineering, and technology imperative for the efficient operation and management of our industries and to sustain and improve our present standards of living.

ENGINEERING EDUCATION AND PRODUCTIVITY

It is difficult to make a self-appraisal and be sure that we are being absolutely honest with ourselves. Fortunately we recently have had an eminent technical authority, Sir Ewart Smith, technical director of Imperial Chemical Industries, Ltd., London, England, make a study of technical education and production in Great Britain and the United States. From these studies he has written a paper, "The Critical Importance of Higher Technological Education in Relation to Productivity,"[6] which was presented to the Section on Education of the British Association in September 1950.

In this study Sir Ewart Smith finds that the productivity per man employed in industry was approximately equal in Great Britain and the United States in 1890. Since that date the productivity in the United States has increased at a compound interest rate of approximately 3 per cent per annum, while in Great Britain the annual rate has been almost exactly half that figure. The result of this difference has been that in 1950 a man in United States industry produced approximately $2^1/_2$ times as much as one in Great Britain. Productivity was measured by the average annual volume of output per man of all industrial employees irrespective of type or grade. As a result of this finding he makes the following observation: "This difference in productivity which has developed during the past half century is, in fact, the basic reason for the economic imbalance between the two countries. . . ."

He also examines the total output of goods or services per capita of the total population. These comparisons between Great Britain and the United States were made product by product and service by service and gave results that are generally similar in each case. The American output is usually somewhere between $1^1/_2$ and 3 times the British, with a long-term rate of increase tending to maintain this lead.

It is admitted in the paper that the reasons back of the long time trends of increase in the United States and Great Britain are no doubt complex, but it is reasoned that the employees are essentially equal in innate ability, that fresh fundamental knowledge as a result of research and invention are essentially equally available in either country, and that essential raw materials can be obtained by any country prepared and able to pay the economic price. Sir Ewart Smith then makes the following statement:

"There is, however, one basic and controllable factor in which Great Britain and the United States differ from each other, namely, in the relative numbers of those trained in applied science. It is the writer's belief that our inferiority in this respect has not only slowed up the rate and efficiency with which scientific and technological knowledge is now being applied throughout industry in this country (Great Britain), but has also led to a lower over-all standard of scientific approach and understanding in the whole field of management—industrial, economic, and political—as affecting industrial affairs. . . ."

The author of the paper also directs attention to two other matters: "The first is the longer graduate and postgraduate training which is now normal in other countries. Secondly, there is a common belief in this country (Great Britain) that a career in applied science in industry is in some way inferior in status to that in the other professions. . . ."

Sir Ewart Smith's investigation shows that during the relatively stable period between World War I and World War II the United Kingdom degrees granted in all applied science (technology) per 100,000 of the population increased only from 1.6 to 1.8 per year, whereas in the United States, first degrees in engineering alone grew from 7.0 to 10.5 on the same basis. The number of first degree engineering graduates per 100,000 population in the United States was 4.4 to 5.8 times the number of graduates from all branches of applied science in Great Britain during that period.

In 1949 the first degree applied science graduates in Great Britain had increased to 3.8 and the first degree engineering graduates in the United States to 28 per 100,000 of population. In that year the number of first degree graduates per 100,000 population in the United States was more than 7 times the number of graduates from all branches of applied science in Great Britain. In 1949 the number of graduate degrees granted in engineering per 100,000 population in the United States was 3.4, which approaches the number of first degree applied science graduates in Great Britain.

A COMPARISON

How does engineering education in the United States differ from that in Europe? Basically the difference is not great. In fact, the early engineering curricula here were patterned after those offered in France and Germany. Then why has engineering education been so much more readily and generally accepted here then in England and even France and Germany where technical education was first established and fostered more than a century earlier? There appear to be at least two very important reasons:

1. While there were—and still are—some academicians in the United States who consider applied science beneath the dignity of a scholar, when engineering curricula were introduced in our colleges and universities, they were not so strongly intrenched here as they were in Europe and hence were unable to discredit the application of science to practical engineering problems and industry. As a result brilliant young men and women have been attracted to the applied sciences and the engineering profession.

2. The early development of our educational system fortunately included a co-ordinated system of secondary and higher education in addition to primary education. This co-ordinated educational system, including State-supported institutions of higher learning, has brought education within the reach of people in all financial circumstances. The existence of these State colleges and universities has resulted in greatly increased numbers of college graduates in all fields, including engineering. Therefore, we have had the necessary supply of engineers to meet our requirements reasonably well until the present critical shortage resulting from a combination of circumstances which have increased the demand and decreased the number of graduates.

I do not wish to imply that engineering education has reached such a degree of perfection that it no longer needs constant and critical attention. It is recognized that we are far short of the ultimate desirable objectives and that the ever-changing requirements for a higher quality of training will be a constant challenge to our best efforts, regardless of how good they may be. We are, however, enjoying a rich heritage of industrial development and a standard of living never before enjoyed in this world and this inheritance, in large measure, may be attributed to the existence, over approximately the past 100 years, of a sound program of engineering education.

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Vision in Power

PHILIP SPORN
FELLOW AIEE

Electric power plays a vitally important role in American life, and demands for its future development are increasing steadily. The efficient planning of future power systems, however, calls for foresight and imagination as well as sound technical judgment.

The role of power in the life of a country like ours is out of all proportion to its economic value as determined by price. First produced commercially here some 70 years ago, electric power today has become an indispensable part of the daily living of most Americans: in the home, in community functions, on the farm, and particularly in industry. In the prodigious beehive of industrial activity that constitutes the strength and achievement of this nation, electric power is the energizing force without which most industrial, and even home activity, would be impossible.

Engaged as we now are in an effort of vast scope to build up our defenses and to strengthen the defenses of other free nations, it is necessary to utilize all our resources to produce armor powerful and plentiful enough to restrain potential aggressors, or to defeat them if war comes. In bringing all this about, power will play a decisive role.

An address delivered before the American Power Conference, Chicago, Ill., March 27, 1952.

Philip Sporn is President, American Gas and Electric Service Corporation, New York, N. Y.

It is even more vitally linked with peacetime progress and our ability to continue to grow and provide for the physical and spiritual welfare of an expanding population.

THE ROLE OF POWER

The true place of power in our over-all picture may be gauged better if these introductory statements are expanded.

First, it is much too categorical a statement to say that power and national welfare are synonymous. Power is vitally important in industry, for example, yet in most industry the cost of power represents a bare 7/10 of 1 per cent of the cost of production. But power can be critically important. It becomes critically important if it is absent.

Second, the role of power is growing. With all the attention that the development of our natural gas industry has been receiving recently and all the optimistic hopes that are being held out for atomic power, these, after all, are forms of fuel and fuel is only one element, though an indispensable one, in the development of power. Electric power is the one form of energy that man has been able to produce that is ideal from almost every standpoint in every sphere of man's activity, and this aspect of electric power is constantly gaining greater recognition.

Third, utilization of power is subject to an unusual rate of growth. It is well known that any given rate of growth may be out of the ordinary for one industry and yet be normal or below normal for another, but use of electric energy is still increasing so fast that its growth pattern is not yet fully established. This characteristic of an undefined growth pattern, by any standard of comparison, can be matched only by very young industry. Truly, in the case of electric power, it can be said: Past is but prologue.

Fourth, the importance of power in national defense cannot be overemphasized. Electric power is one of the key factors in mobilizing our industrial resources. This is true of all defense industry. It is especially true of many special war industries developed in recent years in which power plays an even more significant role than it does in such operations as aluminum reduction or in electric steel manufacture. As cases in point we have the atomic diffusion or separation plants at Oak Ridge, Tenn., the similar plants being built at Paducah, Ky., and other nuclear operations in a less advanced stage of technical development which are now also under construction.

Fifth, electric power has a part to play in assuring peace, or in restoring peace if we should have to undergo the ordeal of war. This is because the bringing about of a condition of peace is inevitably linked up with the problem of acceptance by the masses of the world of belief and faith in our system of freedom—political and social-economic. This in turn is tied to the problem of improving and of kindling hope for further improvement of the lot of the average man all over the world. That improvement cannot come except by mechanization and further improvement in our own productivity as a prelude to helping the less industrially advanced peoples of the earth improve theirs. Of necessity all this involves more electric power.

Sixth, if we are to get maximum utilization of electric power we need the most economical development and the most economical operation. For only by insisting on such criteria will you bring about the result sought with a minimum call on the country's resources and manpower. Production of electric power is a most complex and unique technical-economic operation. Not only does it require large quantities of capital per unit of capacity and energy produced, transmitted, and distributed, but the economics of the enterprise naturally demand a low rate of depreciation—a rate very close to that provided by consideration of physical life due to wear and tear. This requirement calls for a great deal of advance planning to avoid obsolescence due to inadequacy; that, in turn, means long reaches into the future. For unless the fog of the future is pierced by vision, neither size nor technical dimensions can be visualized. As a matter of fact, unless social-economic trends are visualized, the very foundation for future systems cannot be developed. In short, sound development of power systems is not possible unless boldness and imagination—vision—in projection and conception are liberally intermingled with technical soundness and economic responsibility.

NEED FOR VISION

Vision obviously is not introduced merely by making engineering studies and evaluations, or economic projections, even though these activities help. The technical studies, as often as not, stop short just at the point where they need very much to advance. To paraphrase John Tyndall; we cannot stop abruptly where our slide-rule value ceases to be of use. Here vision is needed; here special insight and intuition are required to supplement the purely technical judgment. Vision obviously cannot be confined to things physical in a field such as electric power where perception is needed in the social, social-economic, and even political sphere. Like a good many chemical reactions which cannot occur except in a solution of a certain pH, it seems to me that vision is impossible except against a background of understanding of the life of the community, recognition of the aspirations of the various segments of the population, and awareness of the basis of their economic well-being and of their social habits.

To some extent vision has the characteristics of being both swift and transient. In an instant one may see clearly and boldly a full development, a system, or the consequences of a policy, and in that instant he may get a clear basis for judging intrinsic worth, economic soundness, or basic wisdom of each of these respectively. An almost infinite amount of work may be necessary to fill in various phases of the picture before it can meet, in the light of cold judgment, the test of reason and analysis. It even may be necessary to invent new tools, devices, and organizations not previously tried or known. But unless the end vision is clearly kept in mind these never will come into being, and the end so desirable and desired never will be brought about.

The discussion thus far has been very general in charac-

ter. It should be possible to relate these observations in some measure to concrete experience. Consider, for example, some recent projections into the future made on the American Gas and Electric Company System.

The peak demands of the American Gas and Electric System over a period of a quarter of a century have been as follows:

Year	Maximum 1-Hour Peak Demand (Kw)
1930	614,000
1939	909,000
1951	2,700,000
1954 (estimated)	3,600,000

Thus, between 1939 and 1954, demand will have quadrupled; this is equivalent to a compound growth of 9.6 per cent per year. If this rate of growth should continue to 1970, the system demand at that time will be 15,600,000 kw. The average rate of growth over the period 1930–50 was 7 per cent. If this rate of growth is used to project to 1970, a demand of 9,300,000 kw is indicated. If the 7 per cent rate of growth is used as a basis of projection from the reasonably certain 1954 demand base, then the demand to be looked forward to in 1970 is 10,700,000 kw. Thus it appears that, depending upon what rate of growth is chosen for the purpose of projection, the 1970 demand that may be expected will vary between 9,300,000 kw and 15,600,000 kw.

Similarly, the application of suitable load factors to the peak demand projection indicates a possible system input in 1970 of between 57.2×10^9 and 96.0×10^9 kilowatt-hours. These compare with the 1951 figure of system input of 15.96×10^9 kilowatt-hours.

None of these relatively simple projections have been accepted as serious indicators of what demand and system input are likely to be in 1970. But they have been catalytic in generating a view of a possible growth and development, of there coming into being a complete power system, simply unimaginable only a few years ago. They also have served to bring into focus a host of problems that will be pressing for solution, some of which had not been encountered previously and others which, while they may have been met earlier, will appear in a form so much sharper and more critical as to constitute new problems. As the implications of the outlook are scrutinized, two things are plain:

1. Demands of the order indicated never will come about unless they are visualized, prepared, and worked for.
2. The solution of practically all of the major problems incident to such enormous increase in demand never will be achieved or be worked out soundly unless they are visualized and developed in congruence with the main vision.

THE MAIN CONCEPT

What is the main concept? I believe its outlines are quite clear:

A social-economic institution closely intertwined with the economic functioning and therefore dedicated to meet the requirements in its service area—existing, growing, and expandable to the maximum extent in the future, even when quadrupling of present limits is indicated—on the part of all classes of consumers: urban-residential, rural, commercial, industrial, municipal, county, and state, and other governmental; utilizing for that purpose new aids and instrumentalities, technical and economic, some developed by others, and some by the company itself, to carry out the functions of generation, transmission, and distribution in the most reliable and most economical manner, and so developing utilization of electric energy to the utmost. The objective of all this? To promote the security and social-economic welfare of the community and the citizens it serves, and of all the people co-operating in rendering that service: the owners, managers, supervisors, and the thousands of members of its large family of employees.

The conception goes farther. It includes in its scope service and worth. It definitely reaches a horizon of social usefulness and responsibility as a basis for maximum assurance of continuing to function. This, in effect, merely recognizes the danger of a vacuum created by failure to respond to opportunity or need. Of course, indispensable prerequisites to assurance of continuity of function are trust and confidence in the ability of the country, its institutions, and its people, to progress and move forward.

With that outlook clearly before one, the many problems, some quite difficult, brought about by such growth and expansion as I have indicated, fall into their logical places and all can be worked out and in harmony. Planning, building, staffing, operating, and the problems associated with all of them, take their cue from the main theme.

Consider, for example, the problem of generation and the question of generating plant sites. Who, in the light of the prospects I have indicated, can become careless with a good site or indifferent to the importance and value of developing prime sites sufficiently ahead of need to be sure of availability when actually needed? Who can project a program that involves underdevelopment or underprojection of a good site?

Examine the basic question of fuel. With quantities of energy of the order indicated to be generated, fuel as the one indispensable and most important element in providing mass generation of electric energy becomes something more than a commercial commodity to be obtained as needed by asking for bids from prospective suppliers. The importance of exploring a whole series of questions—sources, reserves, technical and economic soundness of entrepreneurs—becomes apparent. Also, the question of the competitive position of various fuels: coal, oil, gas, char, when and if it becomes a significant commercial commodity, and atomic fuel, when and double "if" it becomes a commercial item—all of these fall into their proper places both as to the present, and in time scale as well.

Again, consider the question of turbine and boiler sizes. I have been told of system planners or executive directors who within the past year or two had declared that they never would have need for units above a certain size, say 50 or 60,000 kw. I do not say that this par-

ticular rating could not have been the ideal rating for that particular system at a certain time. Nor would I deny that larger sized units bring with them additional technical and economic problems. But it must be obvious that only those who visualize inadequately can hobble themselves and the system they project by categorical prejudgment as to what size they will or will not permit to be utilized in the growth and development of their system.

Take the questions of temperature, pressure, and cycle in the modern steam electric plant. All the heated arguments as to whether 900 pounds per square inch, 850 degrees Fahrenheit, constituted or did not constitute a natural limit to further progress in thermal and economic efficiency, and all the fear, uncertainty, and hesitation as to whether to reheat or not to reheat, show up in their true perspective in the illumination furnished by a broad picture of the system and development ahead. How, in the light of expansion potentials such as I have indicated, can one rest on present limits of performance as long as science and technology are opening up new vistas?

For a period of years we have been having controversial discussions about the economics of this or that extra-high voltage: 220, 287, 330, and even 400 kv. I have heard engineers of standing and accomplishment say that they never could see the usefulness of any voltage higher than 220 kv. Yet it is obvious this is no subject that can be even half rationally studied and analyzed until something more than present or relatively close at hand system projections are made and studied. Here in particular, the view of a system going well beyond anything that is called for in the present is a necessary prerequisite for technical development, and for bringing about economic realization in the form of savings in capital and operating costs.

THE HUMAN ELEMENT

Of all the elements that have to be brought together in a soundly conceived and efficiently functioning electric power organization, none is as important as people: the people necessary to visualize, plan, build, direct, and operate; people endowed with skill; people trained in many specialized fields; people of character—productive people. But, in a complex industry like ours, such people can only be found and are only available when needed if they are brought into the industry at the right time, and if subsequently they are properly trained and permitted to develop. But if this need is not projected and communicated to others; to those directing the affairs of our secondary schools, of our colleges, and technical schools, to the faculties of those schools and to their students; how can one expect young people to become enthusiastic about allying themselves with a visionless industry? How can you expect them, by their demand for training and instruction, to exert pressure strong enough to bring into being schools adequately equipped and manned by faculties of high competence and inspiring leadership?

It seems clear to me that the personnel problem—the problem of bringing in the right people and the problem of keeping them inspired, happy, and productive—can be solved only with many years of effort as a part of the conception of the long term picture of the industry. Without this vision, the realization will be patched, partial, inadequate, inefficient, and uncertain. Given this outlook, it can be made whole, fully adequate, sure and harmonious in its functioning, and highly efficient and productive.

Industry today is confronted by problems that, in terms of size and scale, go beyond anything that could have been reasonably projected only a relatively few years ago. For example: one large power group is today wrestling with a problem recently placed before it as a result of our expanding defense effort that in the power field, at any rate, has never before been even remotely approached from the standpoint of size, complexity, and multiplicity of ramifications. I have participated, over the past 6 weeks, in a great many discussions in an attempt to work out a solution. Almost every new discussion reveals a number of new facets of the problem; this in turn presents invitations to go off on attractive bypaths. The number of these would feem to be almost inexhaustible. But the solution of the problem does not lie in exploration of any of these bypaths. If the problem is not visualized in its whole, and all its parts placed in the context of the whole, the solution as a whole most certainly will be exasperatingly difficult, and perhaps impossible.

It seems to me that the same basic relationships apply to and govern all other fundamental problems of the power indutsry. If, on top of its achievements as a social-economic force operating in a complex technical field, the industry can maintain vision, all will be well. The day it loses vision will be a sad day for the industry. And, considering the great importance of power and the contributions that private enterprise functioning in power has made and can continue to make to the welfare of the country, it would be a sad day for the country as well.

Isotron Separation Process Data Made Available to Scientists

Details of one of the early isotope separation experiments, based on a machine called the isotron separator, have been declassified by the Atomic Energy Commission (AEC) as a part of its program to add to basic knowledge available to science. The isotron separator was developed in 1941–42 and was given the deliberately meaningless name of isotron because of war-time secrecy. It is a machine which may be used either to separate isotopes or, as a mass spectrometer, for measuring masses of ions, using the "time of flight" principle. The isotron project was abandoned in 1943 because other methods showed more promise and further studies have concluded that the isotron method is not a practical way of producing isotopes in the quantities needed in the classified work of the AEC. However, the method may be valuable in other types of nuclear physics research, having no connection with separating uranium isotopes.

Double-Channel Bus Forces and Inductance

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WHEN ARRANGED PROPERLY, channel conductors possess certain desirable electrical and mechanical characteristics. Thus, they can be arranged so that the cross section of the resulting bus approaches Arnold's equal inductance cross sections[1] for which geometry the skin and proximity effects are reduced to a minimum. Channel conductors have considerable mechanical rigidity with which to withstand short-circuit forces. Their shape enables an open construction which simplifies ventilation and heat-dissipation problems.

These electrical and physical characteristics render channel conductors especially suited for long, heavy distribution busses where it is desirable to minimize the number of insulating supports so as to reduce the number of possible flash-over points. In consequence, busses comprised of channel conductors recently have come into considerable use as a preferred type of construction in high-capacity generating stations.

To predetermine the operating characteristics of these busses requires knowledge of the a-c resistance, the a-c inductance, the copper temperature under load, and the mechanical forces exerted during short circuit. Equations for calculating all four of these quantities are available for single-phase busses comprised of single channel conductors. But though equations are available for calculating the a-c resistance and copper temperature, convenient equations, in terms of the bus dimensions, are not available for calculating the inductance and short-circuit forces associated with single or 3-phase busses whereof each conductor is comprised of two separated channels located flange to flange as in Figure 1. However, since this construction is that of the now much-used 60-cycle heavy-duty central-station design mentioned here, it is obvious that knowledge of such equations is most desirable to the bus designer.

Such equations were derived. Derivation, though lengthy, is not particularly difficult. The conductor cross sections can be considered, in various fashions, as combinations of parallel-aided rectangular areas. By virtue of the fundamental theorem of geometric mean distance theory, the inductance can be expressed in terms of the geometric mean distances between these rectangular areas. These geometric mean distances can be calculated from known equations. Accordingly, determination of the inductance as a function of the parameters defining the (spacing and cross sections of the conductors of the) bus reduces, in essence, to specific formulation of these geometric mean distances and substitution of them in the general geometric mean distance equation for the inductance.

The equation for the inductance thus obtained comprises some 180 terms. Much simpler equations are to be obtained from this general equation: first, by the use of power-series expansions, and second, by assuming that the cross sections of the conductors can be considered as comprised of line segments.

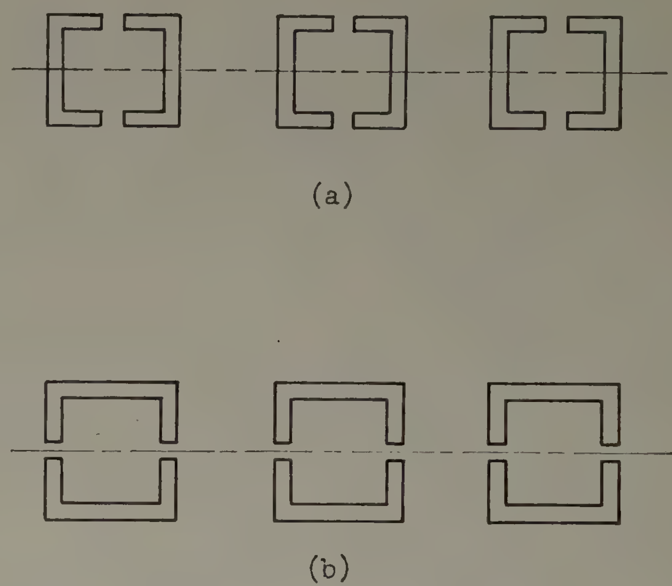

Figure 1. Three-phase busses comprised of double-channel conductors

The mechanical forces acting on bus-bar supports during short circuit are determined both by the magnitudes of the mutual electromagnetic forces exerted among the bus conductors and by the elastic properties of the supporting structure. In consequence of available information on the various factors involved, it happens that if the designer has knowledge of the physical make-up of the bus structure and of the mutual electromagnetic forces exerted among the bus conductors, he can calculate readily the forces on the bus supports. Knowledge of the physical make-up of the bus structure is immediately available to the designer. The desired equations for the short-circuit electromagnetic forces are obtained by simple differentiation of the discussed equations for the inductance.

Finally, application and relative accuracy of these various equations for the inductance and short-circuit forces are illustrated by numerical solution of a typical design problem.

Digest of paper 52-114, "Equations for the Inductance and Short-Circuit Forces of Busses Comprised of Double-Channel Conductors," recommended by the AIEE Committee on Substations and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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This article is based on a thesis supervised by T. J. Higgins and submitted by C. M. Siegel to the faculty of the University of Wisconsin in June 1951, in partial fulfillment of the requirements for the degree of doctor of philosophy in electrical engineering.

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Characteristic Shifts in Oxide Cathode Tubes

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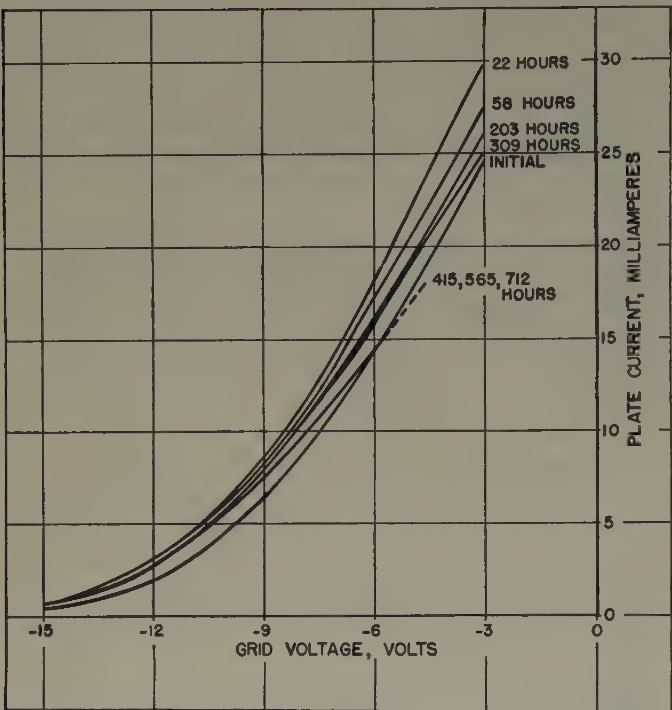

Figure 1. Average static characteristic curve of active cathode tubes as it varies during life

HIGH VACUUM TUBES are being employed increasingly today in applications which require great stability of performance. Whether the application be an electronic instrument, a computer, or a control device, shifts with time in the characteristic curves of the component tubes are very troublesome. This article presents an analysis and experimental results which are intended to help clarify the reasons for such shifts in characteristics.

When the transconductance, G_m, of a vacuum tube falls below a limit permissible for the device in which it is used, the tube commonly is discarded with the thought that its emission is low. As a rule, this is not the case. A tube whose transconductance has fallen below limits may still be capable of delivering several hundred times the emission required by the application.

Aside from possible changes in cathode temperature, an oxide cathode tube operating in the space-charge-limited condition may have its transconductance changed with time as a result of changes in one or more of the following factors: interface impedance, contact potential difference, coating resistance, and peak emission. In the *6SN7GT* tubes studied, it was found that the only significant effects over a considerable period of life were resistive and contact potential shifts. The most important component of resistance was found, in active base-metal cathodes, in the interface compound which forms between oxide coating and base metal. Such interface resistances did not develop in passive cathode tubes up to 3,000 hours under normal operating conditions, but the resistance of the coating itself changed enough to affect the G_m of the tubes. Some of the experimental results are shown in Figures 1 and 2.

Figure 1 illustrates the type of characteristic shift observed in tubes with active base-metal cathodes. In these tubes the cathode resistance increased by 112 ohms, and the contact potential difference between cathode and grid changed by 1.4 volts during the 712-hour operating period covered by the curves. Similar changes, but less in magnitude, occurred for passive cathode tubes. The course of these changes with time is shown in Figure 2, taken over an identical operating period.

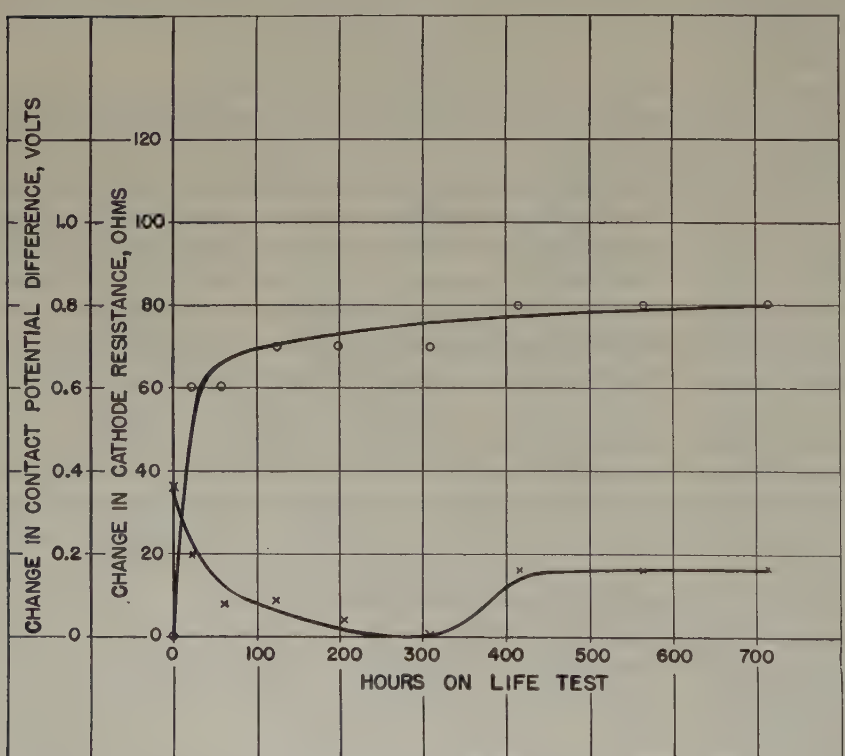

Figure 2. Average changes in contact potential difference (upper curve) and cathode resistance (lower curve) during life of passive cathode tubes

Digest of paper 52-53, "Characteristic Shifts in Oxide Cathode Tubes," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Impressions of European Railroad Electrification

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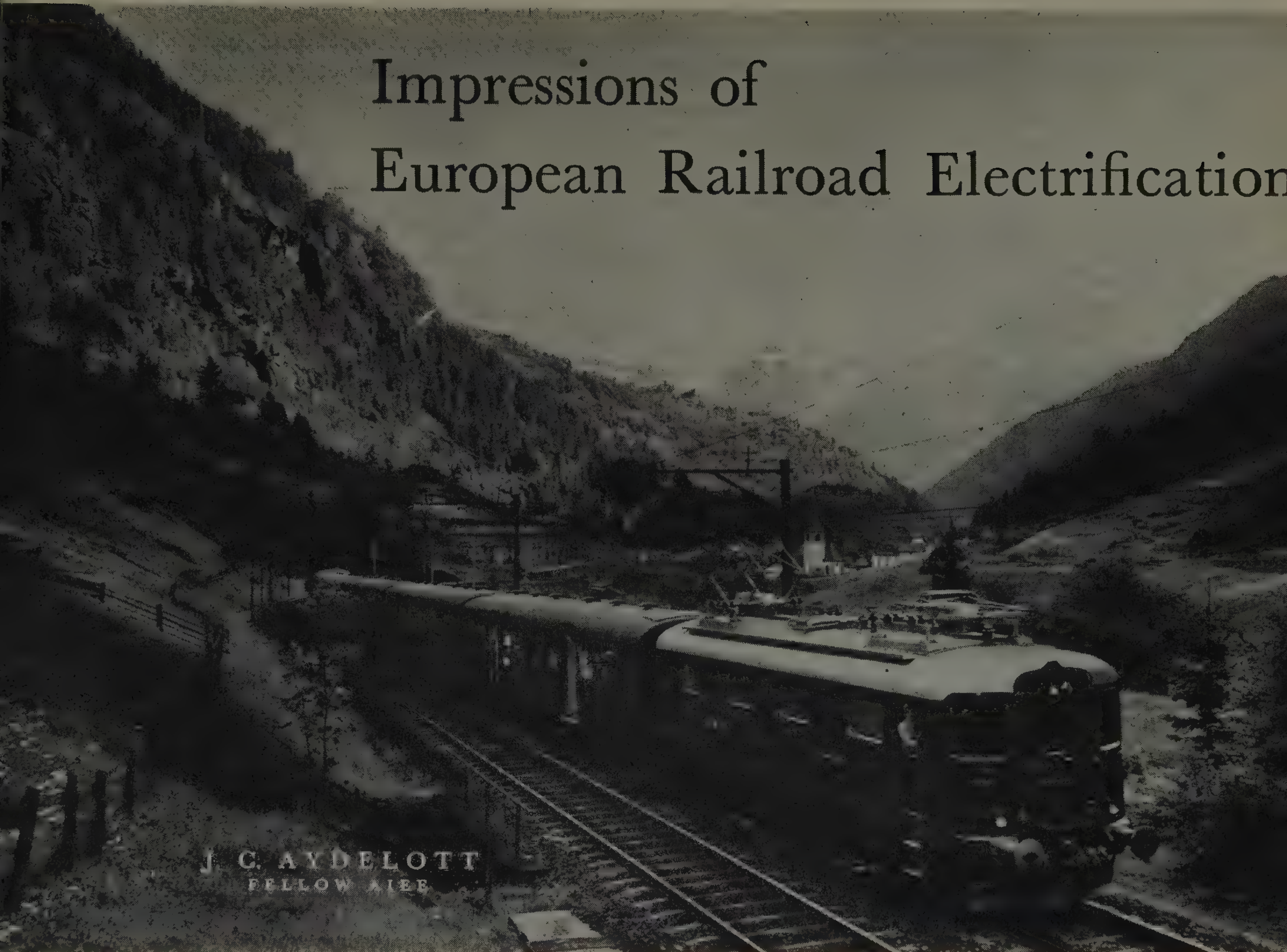

Photo courtesy Oerlikon Company

The electrification of European railroads is different in many respects from that in the United States. In France there is employed a new single-phase 50-cycle system and French engineers have built up a case for this type of electrification. Another departure from American practice is the modern C.F.F. locomotive in the title picture used on the $16^{2}/_{3}$-cycle 15,000-volt lines of Switzerland.

AS SEEN through the eyes of an American engineer, electrified railroads in Europe have many attractive aspects. Since the immediate reaction of "100-per cent Americans" to such a statement will be that what is good for Europe is probably not good for America, it is agreed that there are differences:[1,2] short hauls in Europe versus long hauls in America; relatively light trains versus very heavy trains; locomotives with about 40,000 pounds per driving axle versus about 60,000 pounds per driving axle; rapid accelerations versus nip-and-tuck starting ("drag" operation as we know it seems to be unknown in Europe); and, of course, conveniently located hydroelectric power or low-grade fuel suitable only for large stationary power plants in Europe versus easily transported high-grade coal and plentiful low-cost diesel fuel in the United States. Furthermore, in Europe the railroads and power systems are, in general, publicly owned. Recognizing all the differences, electrification still looks good.

The high horsepower of Europe's electric locomotives is sound. European engineering has progressed to the point where on new designs every locomotive axle is motored, and motored up to the adhesion limit. It is a fundamental of motor design that motor torque largely determines motor weight, or the amount of material needed. A high-horsepower motor weighs little if any more than a low-horsepower motor of the same torque. Within limits this horsepower gain may be thought of as simply applying a higher voltage to the same motor. So why not have high horsepower as long as the material has to be there anyway to develop tractive effort? With the whole power system to draw on, high horsepower is the birthright of an electric locomotive. European designers, taking full advantage of these fundamentals, are certainly not stingy with locomotive horsepower.

As operation on electrified railroads in Europe was

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Photo courtesy Alsthom

Figure 1. The newest French National Railways high-power high-speed C-C locomotive on the 1,500-volt d-c electrification with maximum speed of 160 kilometers per hour

observed, the locomotives are running much of the time at something less than their full power and full speed capabilities. Locomotive tractive effort based on adhesion always must be a limitation. But electrification permits, at little if any extra cost, a type of railroad operation in which locomotive horsepower is not a limitation. It is a wonderful feeling that there is always more there if you want it. Generally speaking, European schedules are fast and, from limited observations, the trains on the electrified railroads in France, Switzerland, and Italy run on time.

SEVERAL SYSTEMS COMPARED

THE WIDELY USED system of electrification in France is 1,500 volts d-c, in Switzerland $16^2/_3$-cycles, 15,000 volts a-c, and in Italy 3,000 volts d-c. Riding the trains in these three countries, the impression is gained that these three systems of electrification are all doing a first-class job. Certainly we cannot look to any differences in the over-all railroading job to be done in the different countries to justify or explain the choice of a different system of electrification. The 1,500-volt system would probably not be adopted today but all of these systems work well.

Most men who are favorably inclined toward railroad electrification, if they stop to think about it, will regret that there are so many systems from which to choose. We all have grown tired of the battle of the systems. Yet let us not say, paraphrasing Shakespeare, "a curse on all your houses." The fact that so many different systems have been made to work successfully is a tribute to the skill and perseverance of many good engineers. The fact that during 50 years the battle of the systems has not yet been decided in favor of any one system, certainly indicates that there is not much to choose between them, and that we will not find an economic superiority in one system over another.

THE ALL-IMPORTANT TRACTION MOTOR

PEOPLE STILL MENTION "wonderful d-c motors" and "terrible a-c motors." If these people imply that they are talking about modern motor designs in both cases, they are trying to be misleading. The first cost of a-c motors is more and the designers must be smart, but difference in motor maintenance is not a factor. To quote an English translation of a recent French paper[3] comparing maintenance costs of $16^2/_3$-cycle a-c versus d-c traction motors:

"The maintenance of electric machines seems to be of the same order for the two types of traction—direct current and single phase.

"Differences in the maintenance which might relate to the method of traction are submerged in the general picture of differences in maintenance due to the variety in the design, the utilization, and in the organization of the maintenance in regard to the various classes of machines, but in any case they are negligible relative to the total expense of maintenance for the locomotive as a whole....

"There thus exists a certain compensation in the maintenance costs of workshop added to those of the depot for the two types of motors; so that we may conclude, as witnessed by the analysis of the maintenance cost of the types of motors chosen, that maintenance of the two kinds of motors is identical or at least costs are independent of the method of traction."

Available figures in the United States, although not published, support these same conclusions. How can this be, when admittedly the design of the a-c commutator traction motor is much more difficult than the design of a d-c traction motor? The answer is almost a definition of engineering: the designer finds a balance between the various elements of cost.

In this study of motor maintenance it is true that the French are building up a case for 50-cycle single-phase electrification. It may be readily said that, for a price, it is possible to build a 60-cycle a-c commutator traction motor; and further, that it can be built to have acceptably low maintenance cost, in line with the maintenance cost of motors for other systems of electrification, that is, about 10 per cent of the maintenance cost of the locomotive as a whole.

Consider comparative first costs of electrification. The traction motor is a good place to start. To do a given job the d-c traction motor costs the least, the cost increasing sharply as the voltage increases. Next, in the order named, come a-c commutator motors for $16^2/_3$ cycles, for 25 cycles, for 50 cycles, and, as mentioned, for 60 cycles. Contrariwise, as is well known, the substation and overhead installations cost less as the voltage increases. It should be noted, however, that increasing frequency tends to offset increasing voltage.[4] For a set of similar conditions, and there is no reason why the voltage should not be the same, the number of substations for a 25-cycle system is between 50 and 60 per cent of the number required for a 60-cycle system.

In passing there may be mentioned urban transit and rapid transit electrification which happily are standardized at 600 volts d-c practically all over the world. In the remainder of this article main-line railroad electrification will be discussed.

CLASSIC APPROACH TO CHOICE OF A SYSTEM

It has been customary in the past to look at a piece of electrification as an isolated problem. It is easy to say that for an installation with many miles and few locomotives, money can be saved by using a system with a low cost overhead even though the locomotives are expensive. On the other hand, if it is a short piece of railroad with a lot of rolling stock to buy, a system offering low cost locomotives should be used, even though the power-supply installation may be fairly expensive. To repeat, this is easy to say, but really is not very sensible when we recognize that most railroads have a variety of such conditions under one management, possibly even contrasting conditions between one portion of the main line and another. People who are sure that one system of electrification far excels any other system probably are looking at only part of the picture.

No railroad management worthy of the name is going to use several systems of electrification for the various divisions of the road. What everyone wants to know is what system is best when we look at electrification for a whole railroad or, beyond that, for all the heavy traffic lines in America. Enough studies have been made in the past to permit some rather sweeping statements about the fallacy of trying to lower electrification costs by finding either a unique solution for each railroad's electrification problem or one system of electrification that will show appreciably lower costs than some other system. These studies have been made from time to time on railroads in various parts of the country with very different traffic and operating conditions. In each case two or more systems have been investigated to see which would show the lowest cost. When everything was added up, the different systems totaled very nearly the same figure, in fact within a few per cent. What was "lost on the peanuts was made up on the bananas" or conversely. It is no wonder that no victor has emerged thus far from the battle of the systems.

RAILROAD ELECTRIFICATION AT INDUSTRIAL FREQUENCY

In view of this evenly matched battle through the years, can we expect a new contender in the field, namely, railroad electrification at industrial frequency, to be outstandingly more economical and, if so, why? Two factors affecting the choice of an electrification system are different today from what they were when most of the present electrification systems were adopted.

1. Industrialized countries today are covered with a network of transmission lines which could make power available to the railroads at not too widely separated points along the right of way. This is in contrast to the day when practically the only transmission lines anywhere were those which the railroads built for themselves.
2. If all the railroads were electrified, the total power required would be only a relatively small fraction of the total generating capacity in any industrialized country. Again, this is in contrast to the early days when the generating stations built for railroad electrification might be as big or bigger than then existing stations built to supply all other loads.

The leaders of the French National Railways (S. N. C. F.) believe that these two factors justify a complete reconsideration of the system of railroad electrification and, most likely, the adoption of single-phase a-c electrification at their industrial frequency of 50 cycles and at 20,000 to 25,000 volts trolley potential.

On October 12 to 15, 1951, at Annecy in the Haut Savoie in France, the S. N. C. F. were hosts to 250 railroad operators and representatives of manufacturers from all the free countries of Europe. H. F. Brown and the author from the United States were also present. Annecy is at the center of a trial installation 78 kilometers in length of single-phase 50-cycle 20-kv electrification. Four locomotives and three motorcar trains were exhibited and 35 papers were presented. The whole meeting was excellently arranged and, as its sponsors intended, certainly served to focus attention on electrification at industrial frequency.

MANY CONSIDERATIONS ARE FAVORABLE

The idea is very attractive that to electrify a railroad it is necessary only to string a light piece of wire up over the track and hook onto some power company's nearby transmission lines. We will, of course, hook onto the same transmission line or other transmission lines at more or less equal intervals along the right of way. Let us note parenthetically that the French[5] propose to solve the interference problem by putting communication lines in underground cables no matter what system of electrification is used.

Why is this idea so attractive? It is attractive for several reasons. Apparently less investment is required. Certainly less investment is required on the part of the railroads themselves, and railroads particularly find it difficult to get money. Furthermore, the system lends itself to piecemeal installation, a little now and a little later as money is available. In these times of distorted economics when a dollar in one account has an entirely different significance from a dollar in another account and it is the

Photo courtesy Italian State Railways

Figure 2. A high-speed main-line train on the 3,000-volt d-c Italian railroad

Figure 3. A new standard locomotive with a-c commutator motors for use on any 25-cycle 11,000-volt electrification in the United States

thing to do to reach into somebody else's pocket for part of the cost, these are powerful considerations.

From all the evidence that came to our attention, the French railroads are receiving full co-operation from the power companies. Perhaps, due to the prevalence of water-wheel generators with heavy amortisseur windings, the possibility of phase unbalance seems to be considered not too serious. Furthermore, the French power companies may be willing to supply power at many points but consider load factor on the basis of the railroad system as a whole. If they do take such a constructive attitude toward railroad electrification, it seems reasonable that there should be an over-all saving in the investment in transmission lines and equipment. The final answer will be expressed, of course, in the rate at which the power companies are willing to sell power to the railroads. No statement has been seen as to how much the French railroads will have to pay the power companies for power on these terms.

UNFAVORABLE CONSIDERATIONS

Many people have been thinking about phase balance. At any one point the railroad load is single phase. The use of Scott-connected transformers[6,7] at each power-supply point probably would be adopted. A 3-phase connection would be made to the transmission line. One of the two secondary phases would feed the railroad to the east of the substation; the other phase to the west. By using Scott-connected transformers there are just two phases to keep equal, which presumably is easier than keeping three phases equal. The 3-phase side, however, will not be balanced unless the 2-phase side is. Furthermore, phase balance is not achieved by using the two phases (or three phases) in turn as a train successively draws power from one section of trolley and then another.

Phase unbalance causes excess heating in the power company's generating equipment and in the 3-phase equipment of other customers along the line. Instantaneous values of unbalance produce heating effects which unfortunately add arithmetically instead of algebraically or vectorially. Phase unbalance, even though it shifts from one phase to another, involves capacity in transmission lines and especially in generating equipment that is not doing useful work.

Over enough miles of railroad, a diversity factor will tend in the direction of phase balance, if the same power company's lines extend far enough and the same generating equipment is involved. Or possibly some kind of switching arrangement can be devised and an automatic control used to transfer some of the load from the heavily loaded phase to the lightly loaded phase.

Railroad operation being what it is, the load factor at the various feed-in points taken individually is bound to be poor and metering, demand charges, and power rates as set up for more easily controllable loads, well may be prohibitive. Possibly a metering system based on a summation of the instantaneous loads at various power supply points can be worked out or the power company may be willing to forego demand charges,[8] assume some reasonable load factor, and simply charge for the total kilowatt-hours consumed.

One way or another, added investment on somebody's part is necessary to handle the railroad load composed of large intermittent slugs of single-phase power. That is, extra generating equipment is needed if the company elects just to take the load as it comes, or some special equipment is needed if an attempt is made to improve the phase balance or local load factor. For the railroad itself to make the lowest investment, all of these things must be expressed in the power rate.

COMPARISON IS STILL A STANDOFF

There are those who say that railroad power lines should be isolated from industrial power lines anyway, and that the only way to get from single phase to balanced three phase is through motor-generator sets. They say further that, when all is said and done, it will be just as economical to install conversion equipment, electrify at a frequency more suitable for railway work, and benefit by lower cost for the motive power equipment.

As was mentioned earlier, we are living in an age of distorted economics which may make it expedient to throw the burden of investment on the power companies rather than on the railroads. Then lower figures in the railroads' capital account may well be offset by higher charges for power. So trying to be objective and looking at the whole picture, when all the costs are added up it is probable that wide-scale railroad electrification at industrial frequency will come out at about the same place as all the other contenders in the battle of the systems. The illusion of getting something for nothing is always attractive, but the lamp of experience does not reveal much basis for optimism.

ELECTRIFICATION IN THE UNITED STATES

What do we see when we view the American scene? There are several successful systems of electrification in this country, but one stands out. Let us take locomotive horsepower as a handy measure. All the electric locomo-

tives in use on main-line railroads in this country today, including terminal electrifications, total just about 2,000,000 horsepower. Of this total horsepower, roughly 70 per cent operates on the Pennsylvania, New Haven, Virginian, and Great Northern under an 11,000-volt 25-cycle single-phase a-c trolley wire, and this percentage is increasing.[9,10] In contrast, scarcely any two railroads with other systems of electrification could interchange locomotives in view of the many different voltages used.

The urge to lower the cost of electrification is, of course, what prompts us to look hopefully at every possible system. But there are other proved ways of getting costs down that are far more effective than starting with a blank piece of paper and a new dream every time the question of railroad electrification comes up.

We are referring, of course, to the genius of American repetitive manufacture. There is far greater benefit to be realized both in operation and in manufacture by standardization than ever can be hoped for by hunting for a unique solution for a given set of conditions on some particular railroad.

There is not much prospect of railroad electrification in this country at the present time but conditions may change. If the day comes when electrification is attractive with one system, it also will be attractive with other systems and therein lies a great danger. Whenever the day does come for new railroad electrification here let us remember the overriding benefits that accrue from familiarity with a job, refinement of design, and improvement of the manufacturing processes—all characteristics of American repetitive manufacture—and let us all agree to use the same system, whatever it may be.

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Physics of Some Loss Mechanisms in Gas Discharges

S. C. BROWN

A simplified analysis of the difficult subject of loss mechanisms in gas discharges is presented to give electrical engineers a good physical groundwork, since these mechanisms often are the controlling features of gas discharge tubes.

THE ELECTRON AND ion loss mechanisms are often the controlling features of a gas discharge tube. The function of this brief review is to point out the physical phenomena which are mainly responsible for the loss of charged particles.

Particles in free space diffusing in a gas of similar particles where uniform flow has been established due to their concentration gradient so that the particles are in a steady state will be considered. The rate of change of momentum in the *x*-direction of the particles due to elastic collisions between electrons and gas atoms is

$$\frac{d}{dt}(nmv_x) = -(mv_x)n/\tau$$

where n = number of electrons per cubic centimeter, m = mass of the electron, v_x = diffusion velocity, and τ = mean free time between collisions. The diffusion velocity v_x is acquired by an electron due to its random collision with the gas in which it is assumed to be in energy equilibrium and this velocity is independent of co-ordinates. The equation therefore may be written

$$\frac{d}{dt}(nv_x) = \frac{dx}{dt}\frac{d}{dx}(nv_x) = v_x\frac{d}{dx}(nv_x) = \frac{d}{dx}(nv_x^2)$$

$$\frac{d}{dx}(nv_x^2) = -nv_x/\tau$$

Revised text of a conference paper recommended by the Electrical Properties of Gases Subcommittee of the AIEE Committee on Basic Sciences and presented at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

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The particle current

$nv_x = \Gamma_x$

and

$v_x^2 = v^2/3$

$$\Gamma_x = -\frac{d}{dx}\left(\frac{v^2\tau}{3}\right)n$$

$$\Gamma = -\nabla\left(\frac{v^2\tau}{3}\right)n = -\nabla Dn$$

where D is called the diffusion coefficient given by

$D = v^2\tau/3$

Since the mean free path $l = v\tau$, this may be written also as

$D = vl/3$

If the motion of electrons in a gas is considered before steady flow has been established, the time variation in concentration can be calculated in any element of space from the continuity equation

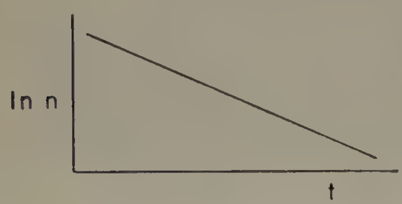

Figure 1. Diffusion loss characterized by logarithmic decay of electron density

$$\frac{\partial n}{\partial t} + \nabla \cdot \Gamma = 0$$

if there is no source of electrons. This leads directly to the diffusion equation

$$\frac{\partial n}{\partial t} = \nabla^2 Dn$$

In the case in which the particle concentration varies with time, the particles diffuse out exponentially so that this process may be recognized experimentally by a logarithmic decay of electron density with time shown schematically in Figure 1. The solution for the diffusion equation yields

$\nabla^2 n = -n/DT$

where T is the decay time of the electron density and $DT = \Lambda^2$ where Λ is the diffusion length. For a cylinder with flat ends of radius r and height h, Λ is given by

$1/\Lambda^2 = (\pi/h)^2 + (2.405/r)^2$

This gives the dependence of the diffusion process on the size of the tube and gives us the expected answer that particles diffuse more rapidly out of small tubes than large ones.

ELECTRON MOBILITY

Under the action of an electric field, charged particles drift through a gas, accelerated between collisions but slowed down by the collisions so that they move at their uniform terminal velocity. Newton's second law applied to such motion yields

$$F = eE = ma + kv = m\frac{dv}{dt} + (m/\tau)v$$

where the damping constant k may be identified with the term m/τ. Solving for the drift velocity

$$v_{\text{drift}} = \left(\frac{e/m}{1/\tau}\right)E = \mu E$$

where μ is called the mobility coefficient and is given by

$\mu = e\tau/m$

In gas discharge discussions, it is often convenient to talk in terms of energy per mean free path which comes out in experimental quantities to be proportional to E/p. Since $v_{\text{drift}} = \mu E$, a plot of v_{drift} versus E/p should be a straight line as indicated in Figure 2.

From the equation for the drift velocity one can see that under the action of a given electric field, the drift velocity is inversely proportional to the applied electric field. Thus electrons in general are travelling many thousand times faster than ions under the same conditions, and the effective temperature of the electrons may be very high while the ions have essentially the same temperature as the gas.

ION MOBILITY

When the energy per mean free path E/p is low, an ion approaching a gas atom polarizes it, and the ion moves in the field of such an induced dipole in much the same way as the case for the electrons just discussed, and leading also to the case of the drift velocity being proportional to E/p.

For high values of E/p, the ion drift velocity becomes large compared to the random velocity so that the energy gained from the field goes into increasing the ion drift energy. The energy gained by the ion from the field is

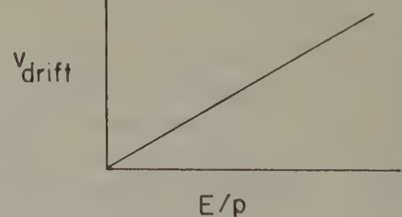

Figure 2. The drift velocity of an electron is proportional to the ratio of electric field to gas pressure

the force, $F = eE$, acting on the ion for the distance l between collisions and therefore

$eEl \sim mv_{\text{drift}}^2 \sim eE/p$

$v_{\text{drift}} \sim \sqrt{e/p}$

The ion drift velocities therefore depend differently on E/p, depending on whether the energy per mean free path is large or small and these simple considerations indicate a variation of v with E/p, such that v varies directly with E/p at low E/p, and as $\sqrt{E/p}$ at high E/p. This dependence of v_{drift} on E/p is shown in Figure 3.

AMBIPOLAR DIFFUSION

When the ion density in a tube is high, the ions and electrons do not diffuse freely but are acted on by their mutual electric fields

$$\Gamma_+ = n_+ v_+ = -D_+ \nabla n_+ + \mu_+ E n_+$$

$$v_+ = -\frac{D_+}{n_+}\nabla n_+ + \mu_+ E$$

$$v_- = -\frac{D_-}{n_-}\nabla n_- - \mu_- E$$

$$n_+ = n_- = n; \quad \nabla n_+ = \nabla n_- = \nabla n; \quad v_- = v_+ = v$$

$$v = -\left(\frac{D_+\mu_- + D_-\mu_+}{\mu_+ + \mu_-}\right)\frac{\nabla n}{n}$$

$$D_a = \frac{D_-\mu_+ + D_+\mu_-}{\mu_+ + \mu_-}$$

where D_a is called the ambipolar diffusion coefficient and expresses the space charge controlled diffusion at high ion densities. The diffusion equation becomes for this case

$$\frac{\partial n}{\partial t} = D_a \nabla^2 n.$$

A simplification may be introduced in the equation for the ambipolar diffusion coefficient if the discharge is in thermal equilibrium; that is, if the electrons and ions are at the same temperature or have the same energy. Using the previously derived equations $D = v^2\tau/3$ and $\mu = e\tau/m$, it may be written that

$$\frac{D}{\mu} = \frac{v^2 m}{3e} = \frac{2}{3e}\left(\frac{1}{2}mv^2\right) = \frac{2}{3}u_{\text{ave}} = D_+/\mu_+ = D_-/\mu_-$$

where u_{ave} is the average energy of the charged particles. Since $\mu_+ \ll \mu_-$

$$D_a = \frac{2D_+\mu_-}{\mu_+ + \mu_-} = 2D_+$$

In other words, the positive ion diffusion is doubled, and the electron diffusion is slowed down to be only twice that of the normal positive ion diffusion. Ambipolar diffusion is the controlling loss mechanism in discharge tubes which support a positive column.

RECOMBINATION

One of the most common loss mechanisms for charged particles in a gas discharge is the recombination of negative ions and electrons with positive ions. The loss of ions due to recombination is proportional to the ion concentration, so that

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = -\alpha n_- n_+$$

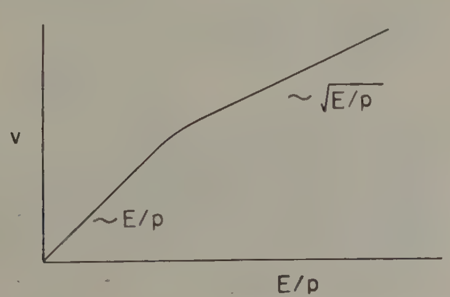

Figure 3. The drift velocity of ions as a function of E/p

This defines the proportionality constant α which is called the recombination coefficient. In almost all discharges the positive and negative ion concentration are equal, $n_- = n_+ = n$, and this equation may be written

$$\frac{dn}{dt} = -\alpha n^2$$

The solution to this is

$$1/n = (1/n_0) + \alpha t$$

n_0 is the initial ion concentration at $t=0$. Recombination phenomena therefore can be recognized experimentally by

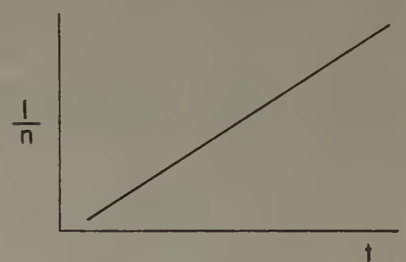

Figure 4. Recombination loss characterized by the linear dependence of 1/n on t

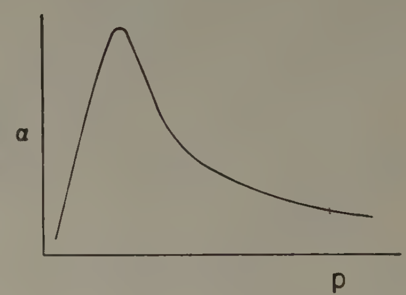

Figure 5. The variation of the ion-ion recombination coefficient with pressure

a linear relation between $1/n$ and t. This is shown in Figure 4.

There are two theories for recombination between negative and positive ions which have been known for a long time; one postulated by Langevin[1] which is applicable to high pressures, and the other due to Thomson[2] which is useful in the low-pressure region. Without going into the details of these theories, the variation of the recombination coefficient with pressure is shown in Figure 5.

The mechanisms of electron-ion recombination are different from those of ion-ion recombination. One common type is radiative recombination in which an electron coming within a close distance of an ion drops into a low-lying electronic orbit, and radiates its excess energy. This is recognized spectroscopically by the afterglow emission of a continuum lying above the ionization potential of the atom or molecule. Another type of electron-ion recombination is called dissociative recombination since it occurs in molecular gases in which the molecule is dissociated in the recombination process. The recombination coefficients measured in the afterglow of discharges by the microwave techniques seem to be of this type.

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Rating and Testing of Power Circuit Breakers

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OTTO NAEF
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IN THE PAST FEW YEARS, with field testing continuing at ever-increasing magnitudes of short-circuit capacity, the controversy over the symmetrical versus the rms basis of rating has taken on more significance. The European claim is that American circuit-breaker ratings must be discounted by a factor of two-thirds, and American manufacturers claim a rating based on the highest possible single-loop offset wave brought about by synchronized pretripping. Although these high American ratings are sanctioned by the American Standards Association, there is no proof that a circuit breaker thus rated is capable of interrupting a symmetrical current of the same rms value. Yet, the definition of rated interrupting current as the highest rms current, including the d-c component, which the circuit breaker shall be required to interrupt, indirectly implies that the two ratings shall be equal.

On the other hand, a network that produces an asymmetrical short-circuit current equal to the rated interrupting current of the circuit breaker is obviously not capable of producing the same rms value of current without a d-c component. There is, therefore, no necessity for the two ratings to be equal.

According to present American practice, the selection of a circuit-breaker rating for a particular application requires that the computed initial value of the a-c component be multiplied by certain factors. These multipliers are different for the momentary rating and for the interrupting rating of circuit breakers having different rated interrupting times.

European standards are based largely on specifications published by the International Electrotechnical Commission.[1] The interrupting rating is equal to the highest symmetrical amperes (or kilovolt-amperes) which the circuit breaker is required to interrupt, and may be supplemented by an asymmetrical rating.

Since the initial value of the symmetrical component is obtained in calculating short-circuit current by the presently accepted method, it would appear logical that the circuit-breaker rating also should be based on symmetrical current. This rating, however, should be supplemented by the requirement that the circuit breaker shall be capable of making and interrupting an asymmetrical current containing the rated symmetrical current along with any value of d-c component up to 80 per cent. This definition covers the possibility that a circuit breaker may have to interrupt the initial asymmetrical current when the short circuit changes its character while the circuit breaker is opening.

Besides current, abnormally high recovery voltages caused by out-of-phase switching and high rates of rise increase the severity of an interruption in various degrees depending on design. While at this time it is impractical to translate these special conditions into specific values, it will be desirable that the standards call attention to them.

To reproduce the severity of ungrounded faults, single-pole factory tests should be made with 1.5 times line-to-ground voltage and 3-phase tests with either the neutral of the power supply or the point of the short circuit ungrounded. To demonstrate the ability to interrupt grounded faults in an effectively grounded system, the test voltage for single-pole tests should be equal to the expected dynamic overvoltage, which may attain 1.3 times line-to-ground voltage.

The degree of severity also is influenced greatly by the instant of contact separation and the amount of asymmetry. If the time from contact separation to final interruption is equal to the minimum arcing-time characteristic for the circuit breaker in question, the arc energy is a minimum. If the contacts separate but an instant later, the arc energy of a whole loop is added. Computed minimum and maximum values of arc energy are shown in Figure 1 for a symmetrical and an 88-per-cent asymmetrical current of equal rms value. The variations are large, the worst asymmetrical case producing more arc energy than the worst symmetrical case if equal minimum arcing times are assured.

It is suggested that agreement be reached on a clause in the ASA Test Code requiring that design tests intended for proving the rating of circuit breakers be carried out with an acceptable degree of severity.

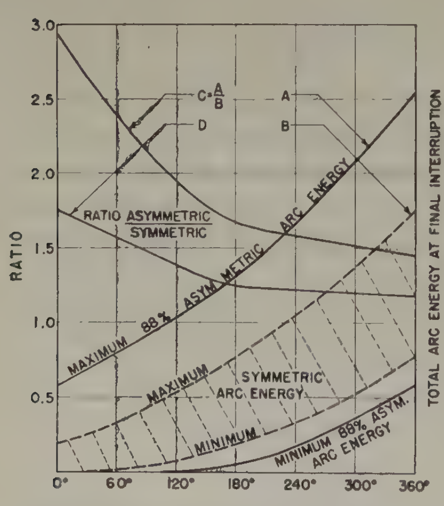

Figure 1. Computed maximum and minimum values of arc energy for a symmetrical current (dashed lines) and an 88-per-cent asymmetrical current (full lines) of equal rms value as a function of the minimum arcing time for successful interruption

Curve C = ratio $\frac{A}{B}$; *Curve D = ratio* $\frac{A/\text{asymmetric arcing time}}{B/\text{symmetric arcing time}}$

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A Metropolitan Transmission System

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IN CONNECTION WITH the installation of Potomac River generating station C, it was necessary to develop preliminary plans for transmission of the energy generated in the new plant to the load. The plans selected have certain features which are not commonplace, such as comparatively small capacity of individual transmission lines, use of phase angle control, and the absence of high-voltage circuit breakers except at the generating station.

The transmission system was designed to meet the following requirements: 1. the capacity must be sufficient to permit full loading of any generating plant at peak time; 2. any additional transmission cost to permit increased loading at other times must be justified by the saving in generating station operating costs; 3. it must be possible to have any generating unit or transmission line out for maintenance, and lose any other generating unit without curtailment of load or dangerous overloads on the transmission system. Provision is not made for the loss of two transmission lines to the same station without load curtailment; 4. it must be possible to remove any transmission line from service at any time without curtailing load, but this may require a deviation from the most economical generating station loading.

Figure 1 shows the new lines installed in connection with the first two units totaling 180 megawatts in capacity. Each transmission cable is a 600,000-circular-mil medium-pressure gas-filled 69-kv 3-conductor cable having a capacity of 45 megavolt-amperes. This cable is described by a previous paper,[1] which gives the reasons for this selection when compared to an oil-filled pipe-type 115-kv cable with three 400,000-circular-mil conductors per pipe having a capacity of 90 megavolt-amperes each.

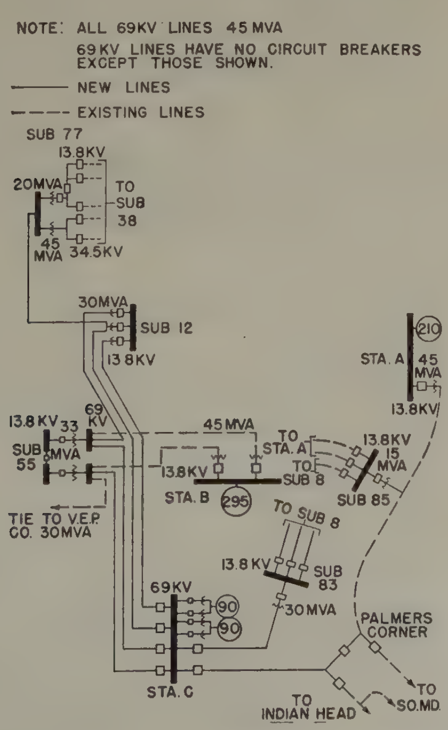

Figure 1. Diagram of transmission added with first two units at generating station C

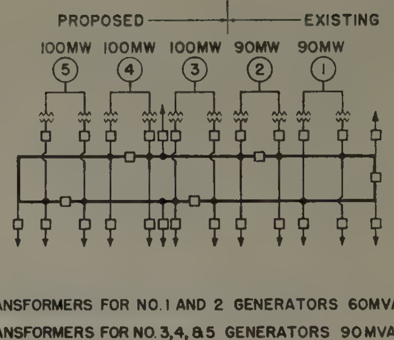

Figure 2. One-line diagram showing major connections to 69-kv bus at generating station C

At each major distribution substation fed by these 69-kv lines, transformers are equipped with tap changing under load with the variable voltage leading the line-to-neutral voltage by 60 degrees or lagging by 120 degrees. This provides phase-angle control permitting control of the load division between parallel lines.

At the generating station, a comparison of a 13.8-kv loop bus with 13.8- to 69-kv transformers in the feeders with a 69-kv bus and step-up transformers in series with the generators showed a saving of approximately $750,000 for the 69-kv bus. Figure 2 shows the plan selected. The station normally will be operated with 69-kv solid bus ties open, but when a generating unit is removed from service at least the bus tie between the two sections supplied by this generator will be closed.

At substation 12, the 13.8-kv bus uses 500 megavolt-ampere interrupting-capacity metal-clad switchgear. There are five feeders supplying a network of government buildings, five supplying low-voltage a-c network transformers, three 13.8- to 4.3-kv transformers, and three commercial feeders. Each 69- to 13.8-kv transformer secondary has two circuit breakers and the bus is divided into five sections. In this way one bus section out of service does not interrupt service to any customers except a few with only one supply feeder.

It is believed that in planning a metropolitan transmission and distribution system, the economic size of the step-down substation may be an important factor in planning the supply lines. Consideration should be given to the use of small-capacity 3-phase transmission cables, elimination of high-voltage substation circuit breakers, and use of phase-angle control.

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Braking Devices for 400-Cycle Motors

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A brief survey is presented of devices used for stopping 400-cycle motors to aid the equipment designer to select the braking mechanism most suited to his particular needs.

THE MODERN airplane requires many kinds of remotely or automatically controlled positioning systems. Cooling-air doors for engines, flight control surfaces, and engine speed control are but a few that require the electromechanical actuator to stop quickly and accurately. This requirement, although simple to state, apparently has been difficult to satisfy, for the number of devices used to attain it are very numerous and opinions as to their desirability vary widely. This requirement, stated in more detail, is that an actuating device must move its load to a certain place, stop it accurately at this place, and finally hold it there until called upon to move again.

Although this article is restricted to stopping devices for 400-cycle motors, much of the data may be associated with the similar problems for d-c systems. The principles used to make 400-cycle a-c brakes also can be used in designing extremely rapid response type d-c brakes.

Stopping devices may be classified into one of the following groups:

Direct current.
1. Brake.
2. Fastop* clutch-brake.

Alternating current.
1. Face-type motor-clutch-brake.
2. Fastop clutch-brake.
3. Brake.
   (*a*). Shaded pole.
   (*b*). Split phase.

SELECTING A STOPPING DEVICE

THE CHOICE of the best stopping device cannot be made without considering two phases of the problem: the user's needs and the degree of difficulty to manufacture. Under the heading of user's needs may be listed kind of control, relative inertia and friction in the load, whether load is friction or overhauling, and availability of the device.

There are proportional, pulsed, and on-off controls.

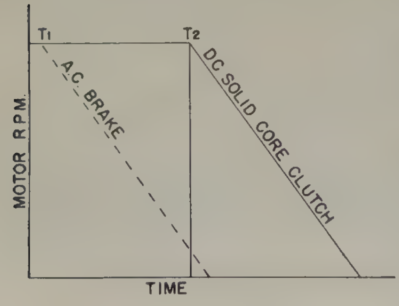

Figure 1. Comparison of motor speed-time curves with d-c and a-c brakes of equal holding torques. T_1 and T_2 are the flux decay times before brake engages. T_1 for a laminated brake may be as low as 0.002 second, while T_2 for solid-core brakes approaches 0.05 second

The proportional control uses a holding device only during periods of failure of power supply or control device. The pulsed systems, such as automatic temperature controls, usually are served best by a clutch to allow the motor to stay continuously near its rated speed. The on-off controls may use any type of device.

The relation of friction load and inertia load are important factors in determining whether to use a Fastop clutch that stops the load only and allows the motor to coast, or a brake that stops the motor armature and load but has about three times the ability to hold the load. In general clutch-brakes should be used with friction loads and brakes with overhauling loads. In some cases the availability of certain types of motor-brake or motor-Fastop clutch arrangements dictate the control. For example, the combination of a d-c brake with an a-c motor requires extra switching and power leads not needed on an a-c brake motor.

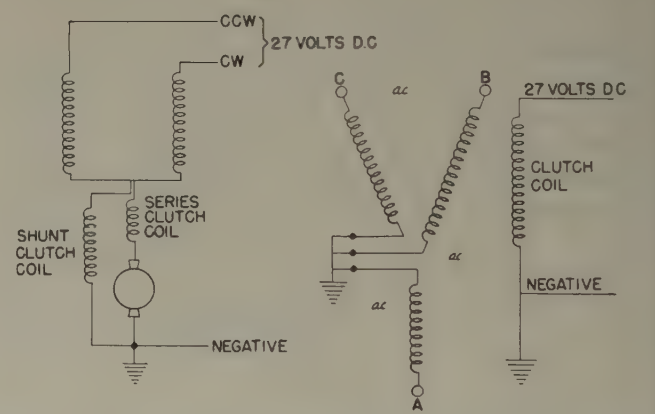

Figure 2. Connection diagrams of d-c (left) and a-c (right) Fastop clutches. Current in the clutch is a function of load torque of the d-c motor

The second item to consider is the manufacture of the device. It may be, for example, that an a-c Fastop clutch has a marginal benefit over a brake but its manufacture may be more difficult and expensive by a large factor. The brake would be used in preference to the clutch.

The stopping device to be used may be a compromise

Essentially full text of paper **52-140**, "Stopping Devices for 400-Cycle Motors," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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between the ideal device for the application and the easiest device to manufacture. A review of the devices in Table I will give some basis for deciding on one or more types.

Table I. Summary of Stopping Devices for 400-Cycle A-C Motors

Type of Stopping Device	Type of Excitation	Kind of Special External Switching Required	Advantages Over Other Types	Major Limitation or Defect
D-c brake	Separate d-c supply or rectifier	Extra contact on control relay	Simplest to fabricate	Brake does not respond as quickly as an a-c brake and requires separate d-c supply
D-c Fastop clutch-brake	Separate d-c supply or rectifier	Separate remote control or extra contact on control relay	Combines clutch action with braking of load only	Holding ability low and requires separate d-c supply
Face-type motor clutch-brake	Motor stator winding is also brake winding	None	1. Brake stops load only 2. Only one electromagnetic structure 3. Minimum total losses of all a-c types	Motor must be short and large in diameter requiring new actuator designs
A-c Fastop clutch-brake	Motor stator and brake are connected internally	None	Brake stops load only	Fundamentally complex or uses brushes
Shaded-pole brake	Brake connected to motor leads internally	None	Requires no d-c power faster response than d-c brake	Inherent high losses per unit torque. Complex and difficult construction
Split phase	Brake connected to motor internally	None	1. Lower inherent losses 2. Simpler to fabricate than shaded pole	Stops entire rotor

The D-C Brake. The d-c brake is the simplest of all the devices to manufacture, but falls short of meeting the user's needs. It requires separate excitation from the motor, extra wiring and controls, as well as an inherent undesirable long flux decay time caused by the eddy currents in its solid core.

During the period of flux decay, the motor is near its rated speed and several revolutions of coast have occurred before the brake has started to resist the load. Figure 1 gives a comparison of speed versus time for a d-c and a-c brake of equal holding torque. This factor alone would limit the use of d-c brakes to a considerable degree.

The D-C Fastop Clutch-Brake. The d-c Fastop clutch-brake has been used on 400-cycle motors with considerable success. Its delay time is estimated about half that of the d-c brake due to its multiple air gaps. The fundamental difficulty is that with the separate excitation required by a d-c Fastop clutch, there is no change in current with load to help increase the slip torque of the clutch when loaded. When using a clutch on a d-c motor, a series coil may be incorporated to increase the torque capacity as the load increases, as shown in Figure 2.

Since the current in the clutch must be sufficient to carry maximum torque at all loads, it is larger for a given torque rating than the current in the d-c Fastop clutch. The motor and clutch having separate power sources, the user may have difficulty timing the clutch and motor starting. This method was used before a-c brakes were available.

The remaining stopping devices given in Table I may be connected to the a-c motor windings internally and require no additional external switching than the motor.

OBTAINING USABLE PULL FROM AN A-C DEVICE

Before discussing a-c brakes and clutches the problem of obtaining a usable force must be defined. Fundamental facts limiting the design of a-c braking devices are

1. The eddy current losses in the solid iron core of a d-c brake are excessive at a 400-cycle frequency and must be reduced to a workable value.

2. The pull of a single alternating flux path at 400 cycles is always positive and goes to zero 800 times per second.

$$F=\frac{K\phi^2}{A} \tag{1}$$

ϕ for an a-c circuit is given by

$$\phi=\frac{e\sin^2\pi ft}{4.44N}10^8 \tag{2}$$

Substituting equation 2 in 1 gives

$$F=\frac{Ke^2\sin^2 2\pi ft}{4.44^2\times N^2}10^{16} \tag{3}$$

Sine squared is always positive and goes to zero 800 times per second if $f=400$.

The first of these two factors requires that an efficient a-c brake or clutch use a laminated structure with flux flowing parallel to the laminations at all times. Any flux crossing laminations would cause excessive excitation current and eddy current losses. An attempt was made to develop a brake using a powdered iron coated with plastic to limit the eddy current losses.

The curves in Figures 3 and 4 show the results of this approach. At the operating force for a particular brake the ratio of power for equal force was 3.91 with the brake closed. With the brake open the working force of 3 pounds was not attainable. Thus the magnetic path must be of high permeability in the direction of flux flow. A somewhat similar set of curves was obtained with sintered iron which gives about twice the power per pound pull. The necessary lamination of the core greatly limits the geometry of the a-c brake or clutch.

METHODS OF OBTAINING CONSTANT PULL

The second of these factors requires a phase shift of part of the air gap flux to produce as nearly uniform pull as possible. A-c motors and a-c brakes are very similar if motor torque and brake pull are thought of in a comparative sense.

The same methods of phase shift may be employed by both a-c motors and a-c brakes except that some polyphase brake designs have been made using shaded poles whereas shaded-pole polyphase motors are practically nonexistent.

Among many of the phase splitting devices used in single-phase motors are the shaded-pole, capacitor-split, capacitor-start, and repulsion-start-induction-run. The latter two types require rotation of the secondary to generate a speed

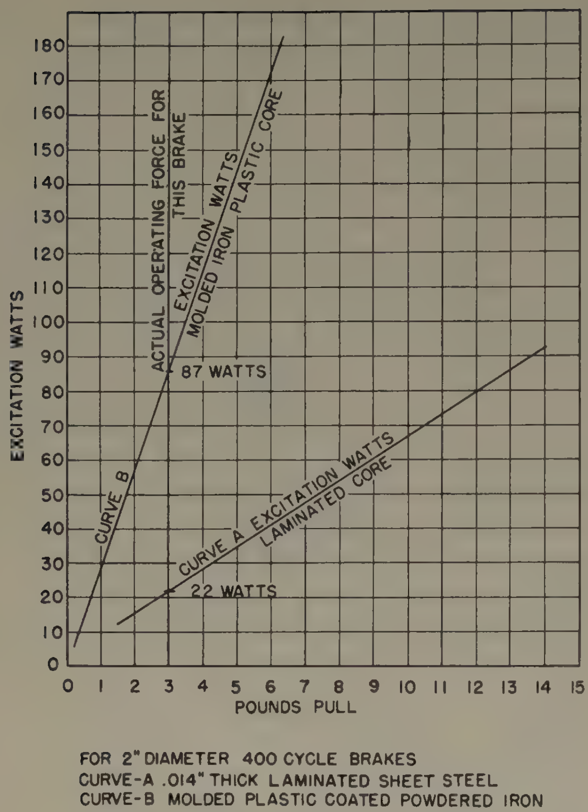

Figure 3. Curves of excitation power versus pulling force in the normally closed position of laminated and plastic-coated powdered iron core brakes of equal size

voltage or to operate a centrifugal switch. A brake armature having no motion cannot utilize these two methods. Thus a-c motor brakes and clutches are left with shaded-pole or capacitor-split method only.

Phase split by shading is accomplished by introducing an I^2R loss in a portion of the flux path. Phase shift by a capacitor is accomplished by cancelling inductive reactance with capacitive reactance. From the standpoint of losses per unit of pull, the capacitor-split brake has a fundamental advantage over the shaded-pole brake.

The Face-Type Motor Clutch-Brake. The stator flux of the motor produces a large radial and constant component of force that is unused at present. Some axial force can be obtained by displacing the rotor, but the pull is nearly zero for considerable displacement and is zero when the rotor is in its normal operating position. Also, displacement reduces the effecting active length of the motor by twice the displacement.

A face-type motor would utilize all of the pull available in the air gap flux. A preliminary study of such a motor immediately shows the possibility of very large forces at no excitation cost and without impairing the performance of the motor. As soon as the motor is energized the rotor moves to its designed running air gap to release the brake and engage the clutch. Earlier studies of face-type motors have indicated that this type of motor should have a large ratio of diameter to length compared to conventional drum-type motors. A diameter ratio in the order of 6:1 has been used successfully.

The actuator designs at present are predicated on motors whose diameter to length ratio is in the range of 0.2:1 to 0.4:1. Linear actuators usually have the motor in the same axis as the torque tube and screw. This arrangement requires a minimum of space in one plane, thus allowing the actuator to be mounted in many close spaces. A face-type motor of large diameter mounted in this manner would increase the thinnest envelope dimension out of usable proportions. Mounting the motor at right angles to the gear train axis would require a departure from conventional actuator design.

The face-type motor also would lend itself to very flat gearing for a rotary actuator, considering the large diameter in which to space the gearing, but requires basically new designs. Therefore, the present configuration of both linear and rotary actuator must be abandoned to utilize fully the face-type motor.

The A-C Fastop Clutch-Brake. The a-c Fastop clutch-brake is the next item given that needs consideration at this time; the importance of the clutch to release the motor armature from the output shaft during braking was evidenced by the extensive use of the Fastop clutch on d-c motors. As a general rule the apparent inertia of a motored actuator is about 90 per cent motor and only 10 per cent load. Even in an aircraft gun turret, which is a very high inertia load, the actual measured data on one turret gave 94 per cent motor inertia and 6 per cent apparent load inertia. This accounts for the fact that Fastop clutches do not need to produce as much holding torque as a brake to accomplish the same stopping time for the usual type of loads.

Attempts to devise a Fastop clutch have led to either of two fundamental approaches. One is to rotate the windings with the motor shaft and incorporate slip rings and

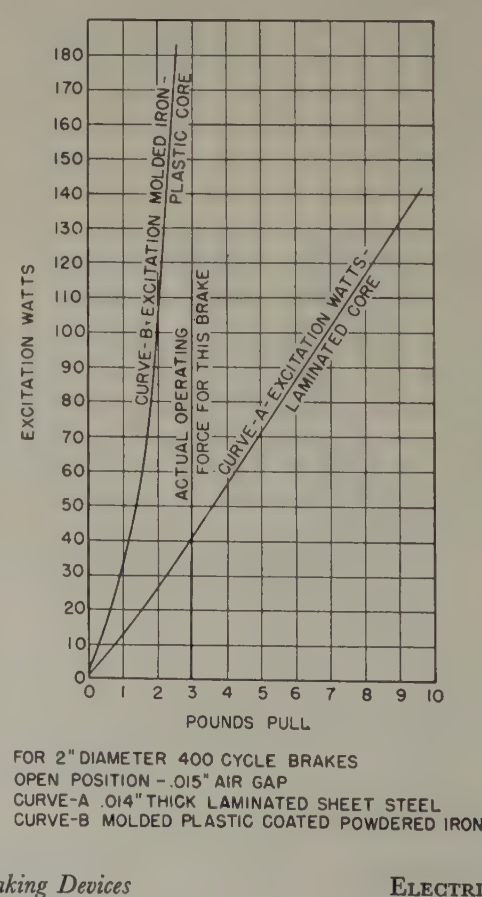

Figure 4. Excitation power versus pulling force in open position for laminated and plastic-coated powdered iron core brakes of equal size

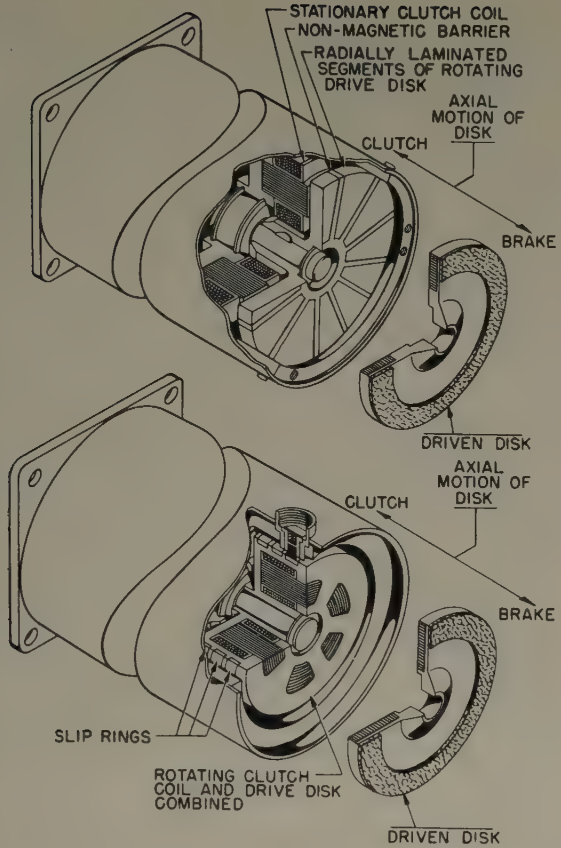

Figure 5. Two designs of a-c Fastop clutches. The disks are splined to the output pinion not shown

brushes; the other is the use of a radially laminated rotating drive disk to carry the flux from the exciting poles to the driven disk. The sketches in Figure 5 illustrate these two basic approaches. The desire to avoid the use of brushes on a-c motors and the problems of fabricating a radially laminated disk have prevented actual production of the a-c Fastop clutch.

The Shaded-Pole Brake. The brake shown in Figure 6 may be considered as three interrelated single-phase solenoids acting on two symmetrical armatures. Variations in pull are decreased by shading and by using alternate poles for return flux paths. The braking surfaces being on the circumference of the brake yields a maximum stopping effort for a given spring force but tends to crowd the electrical components into a small diameter. Only about two-thirds of the pull generated is effective because the opposite ends of the armature are not excited in time phase and the shading cannot produce constant pull. The starting torque of the associated motor tends to bind the armature, requiring additional margin in designed pull. The center pole must be ground shorter than the others by the sum of all manufacturing tolerances to insure that the armature does not rock. This additional gap, the binding caused by starting torque, and the inherent inefficiency of shading all tend to increase the size and power consumption per unit of holding torque. The four carefully paired double-ended springs mounted on rollers holding the laminated armatures constitute a critical manufacture and assembly problem. The steel-lined drum is difficult to fabricate and has a large inertia compared to a thin disk.

This type of brake gives good stopping from speeds of 12,000 rpm to zero varying from 10 motor revolutions for about a 2-inch diameter to 30 for a 4-inch diameter motor. The inherent phase shift available in polyphase voltages is not used and is one of the fundamental limitations of this type of brake.

The Split-Phase Brake. If the poles were so arranged that the forces of each were always acting on the spring and were balanced at all times, a constant pull could be obtained without resorting to shading with 3-phase excitation. This is accomplished by the split-phase brake sketched in Figure 7. The total flux across the air gap is the sum of these equal fluxes 120 degrees out of time phase, resulting in exactly constant flux. This form of brake has constant balanced pull with no losses except winding resistance loss and slight core loss.

The flux all travels in cylindrical surfaces both in the axis of the brake and circumferentially. Therefore, the core is laminated in essentially concentric rings. In 2-inch diameter and smaller motors only four poles are used instead of the theoretically perfect six in order to get a space utilization of at least 90 per cent. With constant insulation thickness and clearances a 6-pole brake has better space utilization for motors larger than 2 inches in diameter.

The laminated core is integral with the steel bearing insert and is pressed into the aluminum motor end bell to simplify construction and to use all parts for as many purposes as practicable. The brake is ideal from a manufacturing standpoint as it can be made for a reasonable cost with practically no tooling, and yet is capable of considerable cost reduction when designed and tooled for quantity

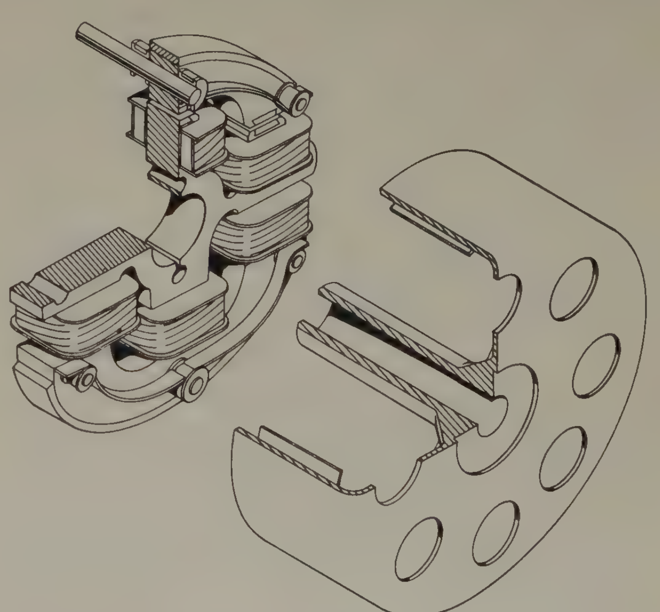

Figure 6. Sketch of a 3-phase shaded-pole brake

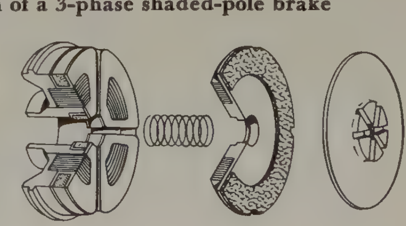

Figure 7. Sectional drawing of a laminated split-phase 4-pole brake

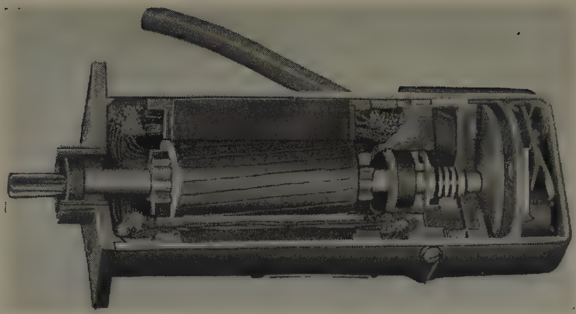

Figure 8. A sectional brake motor showing internal details of the split-phase brake applied to an actuator motor

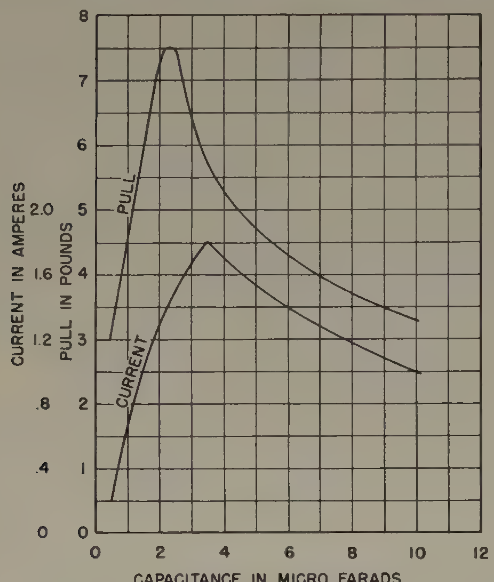

Figure 9. Single-phase pull and current versus capacitance for a 2-inch diameter 4-pole brake

production. There are no critical parts and all pole pieces are ground at one height. The armature is a laminated scroll wound against a steel backing for rigidity.

After carefully considering all these factors, the split-phase brake was adopted as the best compromise for immediate use on 400-cycle motors. Some performance and design data for a particular 4-pole 2-inch-diameter brake are discussed to exemplify the possibilities of this type of brake.

DESIGN AND PERFORMANCE

The simplicity of electrical design hardly merits discussion with the exception of the degree of saturation to use and the correct capacitor to obtain phase split. Although both items are capable of calculation it was found far more expedient to take a test curve to determine the best capacitor value.

Saturation should be based on a density suitable for operation with the worst combination, namely, two phases at 120 degrees. This allows the use of one set of coils for single-, 2-, or 3-phase operation. The size of core was determined from the density at maximum voltage and minimum frequency whereas the spring tension is limited by the maximum spring tolerances associated with minimum voltage and maximum frequency. Therefore, the brake is designed to operate and test at 70 per cent of rated voltag

When used on single-phase motors, a capacitor is re quired to obtain the phase split. A plot of brake pull ver sus capacitance is given in Figure 9. A compromise capac itor of about 1 microfarad is used for this brake to preven high capacitor winding currents. A 3-lead reversibl single-phase motor uses identical brake coils on the main an

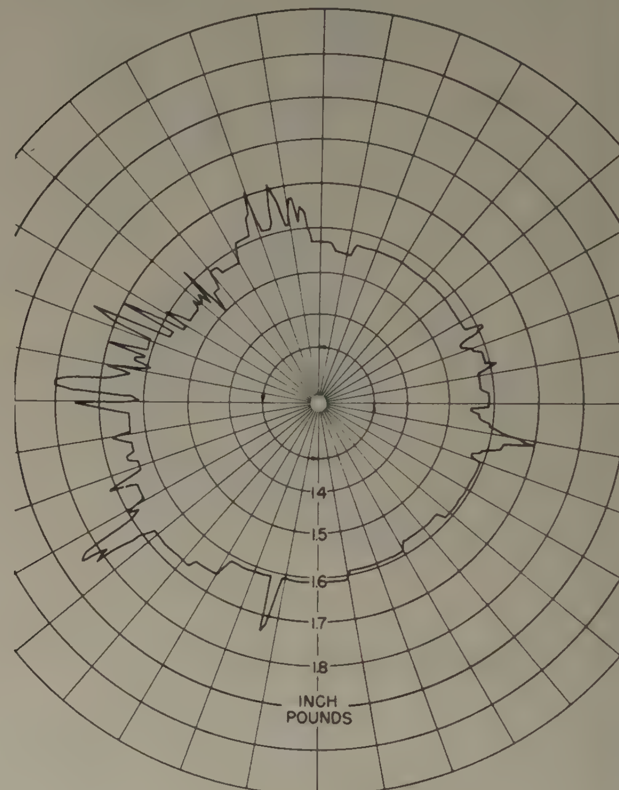

Figure 10. Polar plot of holding torque variation in one revolu tion of a typical brake

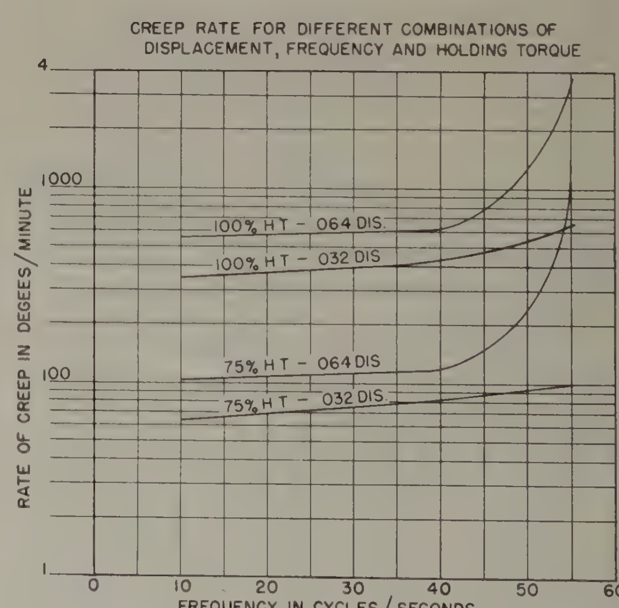

Figure 11. Family of curves relating brake creep rate to vibratio frequency for displacements of 0.032 and 0.064 total amplitud with opposing torque equal to 100 and 75 per cent of averag static torque

capacitor phase for simplicity of switching, whereas considerable capacitor size reduction could be obtained both for the brake and motor, if reversing relays were used allowing more capacitor winding turns.

Further study is being made of the effects on brake and motor performance when connected to a single capacitor equal to the sum of their individually required capacitors. It is thought that the ratio of brake and motor reactances should be nearly the same as the ratio of capacitances to produce minimum change in characteristics when connected to one capacitor.

Figure 10 shows an actual test curve of holding torque versus rotor position for one motor. The average torque is 1.6 inch-pounds. Peaks as high as 1.8 are usable as holding torque whereas the average torque determines the amount of coast. These torques were obtained using a 3-pound spring and a brake armature slipping against an anodized aluminum disk nearly 2 inches in diameter.

The number of revolutions of coast at no load varies with the stacking height of the associated motor from 3 to 10 revolutions for 1/2- to 2-inch stack lengths, respectively. A small d-c motor using a 400-cycle brake wound for d-c excitation stopped in $1^1/_2$ revolutions at no load from 6,000 rpm.

All the various brakes discussed will creep at a slow rate under certain vibration conditions. Figure 11 gives creep rate versus frequency for this brake. Tests on all available types of brakes indicated a rapid increase in creep rate above 40 cycles per second forced vibration. The most practical answer to this problem on the very few reversible actuators having an overhauling load has been to isolate the brake from vibration frequencies above 10 cycles per second.

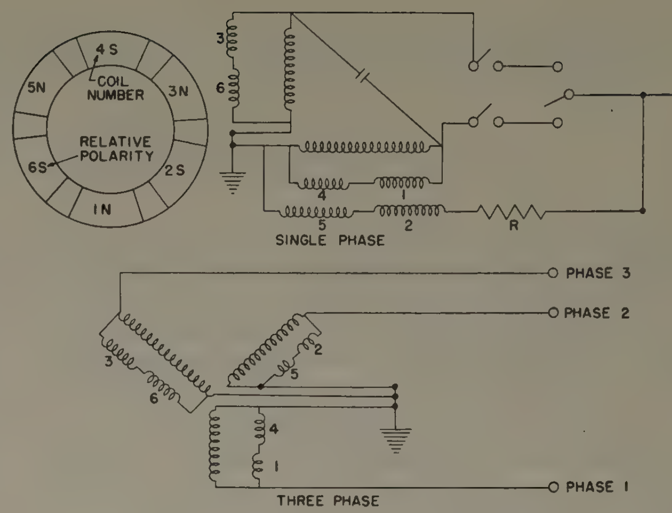

Figure 13. Connection diagrams for 6-pole split-phase brakes

Connection arrangements for 1-, 2-, and 3-phase power are shown in Figures 12 and 13 for 4- and 6-pole brakes, respectively.

In the case of the 4-pole brake one design of coils can be connected for single phase, 2 phase, or 3 phase without any change, as the voltage per coil is constant. As examples of its versatility, this brake is now in production on a 3-wire single-phase reversible motor for jet-engine air-door actuators and is being applied to both the servo motor and the emergency motor on an accurately positioning throttle-control servo.

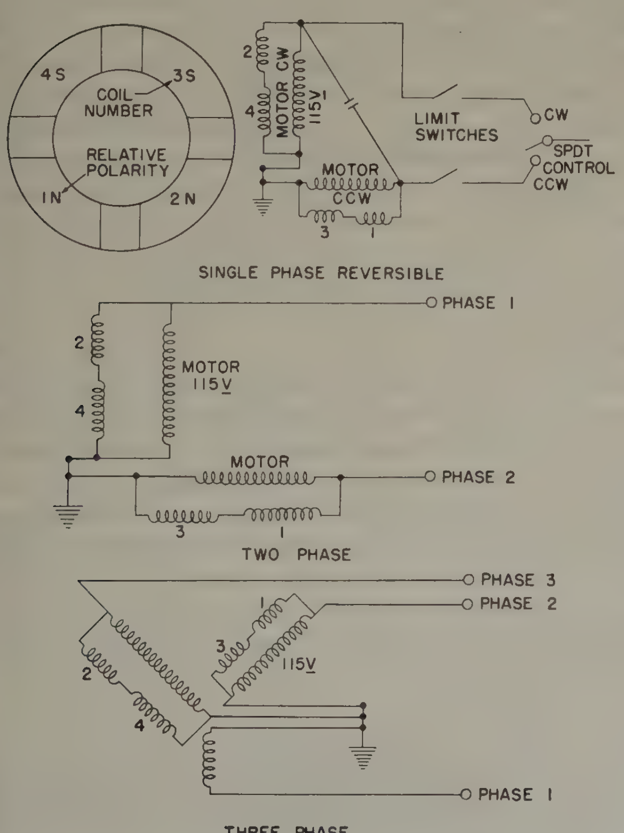

Figure 12. Connection diagrams for 4-pole split-phase brakes

Electronic Memory Device Reports Data on Power Plants

As many as 400 different conditions in an electric power plant can be automatically reported, recorded, and printed by a new device which is going to be installed in the Johnsonville, Tenn., power plant of the Tennessee Valley Authority by Taller and Cooper, Inc., Brooklyn, N. Y. The automatic data recorder and annunciator which employs electromechanics and electronics, will report, record, and print when and where the conditions occurred, and when the situation was restored to normal. It will automatically show normal operations as well as any deviation from the normal in transformers, boilers, turbines, circuit breakers, and other auxiliary equipment. It has a memory device which can store up to 26 different reports on occurrences which can happen as close as 0.010 second apart. It will then feed this information to the recorder and printer. It should enable power plant workers to devote their entire attention to operations leaving the plant engineers to determine the efficiency of power units. The new precision instrument is applicable to airport dispatching, bus terminal control, and in industrial plants where production and quality control is essential.

Exciter Polarity Reversals in Aircraft Alternators

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THE USE OF a-c generators in aircraft has posed some new problems. One of these is co-ordinating the excitation system design with the alternator design to obtain satisfactory performance during transient conditions. There has been much concern over the tendency of exciters to reverse polarity under the conditions of initial build-up, and when a short circuit is applied to the alternator. The tendency is most pronounced on wide-speed-range machines operating near their maximum speeds.

This article deals with a system consisting of a synchronous alternator with a built-in exciter, a carbon-pile voltage-regulator, and feedback stabilizing elements. The wiring diagram of such a system is shown in Figure 1.

The problem is to determine by analysis those features of the design which contribute to exciter reversals, and to suggest design features for various components of the system to eliminate the reversal tendency.

A quantity which correctly measures the reversal tendency is the exciter field current. Accordingly, the equation is derived for this current as a function of time during transients. This equation shows directly the influence of the factors of design. Several examples serve to illustrate methods of improving performance of the excitation system.

Preventing reversals under fault conditions is basically the same problem as preventing them during build-up. It is one of preventing the total voltage drop in the exciter-armature circuit from becoming larger than the voltage generated in the exciter armature.

In general, the analysis shows that the following steps are appropriate for both the build-up and the short-circuit conditions:

1. An effort should be made to reduce the contact drop of altitude-treated brushes.
2. The exciter copper and iron should be proportional so that a weak cumulative-series field winding may be used. It should be noted that a rigid specification upon the upper and upon the lower limits of resistance in the carbon pile may make it impossible to achieve this objective.
3. The voltage rating of the exciter should be raised as much as possible, the limit being set by allowable size and weight, and by the possibility of commutator flashover at high altitudes.
4. The short-shunt connection should be used in the exciter. The resistance of the exciter armature should be made as low as possible, the limit being set by space and weight requirements.
5. The rate of response of the regulator should be as great as possible.
6. If a design is made in which there is substantially no damping in the exciter magnetic circuit; for example, if the frame is made of laminated steel, the possibility of reversal during the build-up transient, due solely to the feedback signal, should be considered carefully.

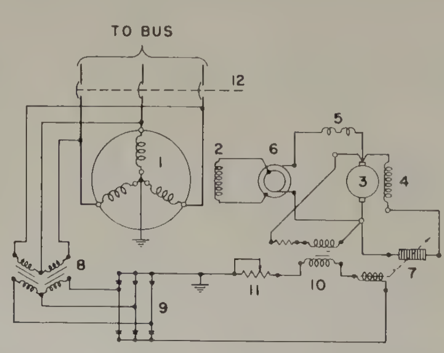

Figure 1. Typical aircraft alternator and regulator system. 1. alternator; 2. alternator field; 3. exciter armature; 4. exciter shunt field; 5. exciter series windings; 6. slip rings; 7. carbon-pile regulator; 8. line transformer; 9. rectifier; 10. stabilizing transformer; 11. rheostat (a-c voltage adjustment); 12. circuit breaker

It has been recommended that the exciter design include a cumulative series winding. However, it may be found that when the desired compounding winding is added to prevent polarity reversals under transient conditions the regulator loses control under steady-state conditions. This objection can be overcome by the addition of a differential shunt field in the exciter. This field is proportioned so that its ampere-turns either partially or completely balance the cumulative series ampere-turns during steady state.

During transient conditions, however, the series turns are free to provide the necessary cumulative compounding. Consider first the transient build-up. It will be assumed that the voltage overshoot is sufficient to open the carbon pile. Then, the source of voltage for the differential field is practically zero, and the cumulative series ampere-turns are not cancelled. When the carbon pile again closes, the field of the exciter builds up with the correct polarity.

Similar advantages are found during short-circuit transients. The effectiveness of the series field is not reduced appreciably by the differential field because the voltage on the latter is practically zero at the critical time of the transient. Although demagnetizing currents are induced in the main and the differential shunt fields in their attempts to maintain constant flux-linkage, these currents decay very rapidly. The cumulative series field strength of course follows the decay of the alternator field current. The net result is that the exciter flux is held positive during the time of the transient and polarity reversal does not occur.

Digest of paper 52-60, "Exciter Polarity Reversals in Voltage-Regulated Aircraft Alternators," recommended by the AIEE Committees on Rotating Machinery and Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Gaseous Insulation for High-Voltage Transformers

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SULFUR HEXAFLUORIDE in high-voltage apparatus fulfills these requirements of a gaseous dielectric: 1. dielectric strength should be high at a low-gauge pressure; 2. temperature of condensation should be equal to or lower than that at which the apparatus is operated; 3. the gas itself and its products of decomposition should not be toxic or of readily controllable toxicity. Similarly, the gas should not corrode materials of construction; 4. the gas should be chemically inert and thermally stable; 5. it should have a high heat transfer coefficient.

The dielectric strength of sulfur hexafluoride is well established at a high value. For example, compared with air or nitrogen, sulfur hexafluoride is two- to sixfold dielectrically stronger, depending upon field conditions, pressure, and characteristics of the voltage wave applied. It has been found that with a 1.5x40 microsecond positive impulse wave at atmospheric pressure the strength of SF_6 is three to five times that of air in various gap spacings. Generally as the pressure rises this ratio diminishes but remains above a value of 2 at 30 pounds gauge.

In contrast, the relative 60-cycle strength of SF_6 to air is within the approximate range from two to three with varying pressure from zero to 40 pounds gauge.

The variation of the dielectric strength of SF_6 with temperature, but at constant pressure, is shown to be essentially linear and related to the variation of the density of the gas with changing temperature. Conversely, the gas at a fixed density, obtained by enclosing it in a rigid volume at some initial positive pressure, will have a dielectric strength independent of changing temperature.

The reactions of sulfur hexafluoride to spark-over and heavy current short-circuit arcs, in common with other complex gaseous substances, produce simple substances. These are in major proportion the lower valence fluorides of sulfur, such as SF_2 and SF_4, and these are toxic.

In collaboration with the Applied Physiology Laboratory at Yale University and with the Allied Chemical and Dye Corporation, General Chemical Division, the following descriptive summary of all the tests can be presented.

In a 10x10x10-foot room about 32 pounds of arced sulfur hexafluoride can be released without exceeding the 7.5 per cent of arced gas which is the concentration of no observable physiological effect on rats. The nonlethal concentration is 20 per cent in an exposure time of 10 minutes and this limit corresponds to 83 pounds of arced gas in the same room. Exposure times of less than 10 minutes are assumed to be less effective.

The practical means for reducing the concentration of toxic impurities resulting from an arc breakdown is by the use of an alkali, such as solid sodium hydroxide or an absorbent solid, such as activated alumina. The latter, with sufficient area exposed, as in a screen tray, in 1 hour removed all the SF_2 and SF_4 by infrared analysis produced by a power arc in a 6-cubic-foot test tank.

The purely thermal stability of sulfur hexafluoride is shown by passing the gas through clean copper turnings at 500 degrees centigrade. No change in composition is found by infrared absorption analysis. As the temperature is raised to 600 degrees centigrade, however, the absorptions due to SF_2 and SF_4 begin to appear.

As a cooling medium, sulfur hexafluoride is appreciably more effective than air. It is estimated that with free convection the heat transfer of SF_6 at 30 pounds gauge is about 2.5 times that of air at the same pressure. In a tank containing a heated coil the coefficient of heat transfer at atmospheric pressure is 0.005 watt per square inch per degree centigrade, or 1.6 times that of air under the conditions stated. In another test, a 3-phase dry-type distribution transformer, the temperature rise is reported to be about 75 per cent that of air alone, when 67 per cent of SF_6 is mixed with the air. This is for the hot spot over ambient of the low-voltage winding. The average temperature of the high-voltage winding is reduced to 86 per cent of that in air alone.

The correlation of all of the known properties of sulfur hexafluoride now allows the reasonable consideration of its possible applications together with an evaluation of its advantages and disadvantages.

An experimental 138-kv developmental transformer is reported to be operating at a pressure of 15 pounds gauge after nearly 2 years at 1.87 times the normal voltage. There was no sign of decomposition after 14 months and all indications point to continuing operation into the indefinite future. It is therefore possible that SF_6 will replace air in dry-type transformers. Railroad transformers might be improved by a change-over to SF_6.

The use of SF_6 in X-ray apparatus is apparently being extended along similar lines to 250-kv therapy and 100-kv diagnostic apparatus in which the gas can be employed at atmospheric pressure. Since it has been found that a small amount of air can be admitted, filling the apparatus can be quite simple—upward displacement of air by the fivefold heavier SF_6.

Under pressure, the dielectric strength of sulfur hexafluoride can be made to equal that of 10 C oil. With this accomplished, further applications are possible. That the gas is inert, nonflammable, and nontoxic must be considered.

By eliminating solid insulation in some applications, the use of SF_6 also eliminates the possibility of a permanently weakened spot in the apparatus if an arc-over should occur. The gas is "self-healing."

Digest of paper **52-78**, "Gaseous Insulation for High-Voltage Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Specific Objectives of Electrical Engineering Curricula at the Undergraduate Level

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Inadequate teaching of humanities, neglect of the fundamentals of engineering, and overspecialization are criticisms of engineering curricula that are reviewed and analyzed by the author. Suggestions and future plans designed to improve engineering education are given.

So much has been said and written about undergraduate engineering curricula; what they should or should not contain, what their shortcomings are, and how they do not prepare students for graduate work, for industrial life, for the specialization needed by industry, or for life as a member of organized society, that it seems almost useless for me to add to this volume of discussion.

One has only to peruse the pages of *Electrical Engineering*, to delve into the Proceedings of any one of the engineering societies, or glance through a few volumes of the *Journal of Engineering Education* to realize that almost everyone has ideas on what is wrong with engineering education.[1] Indeed, it seems that everyone feels competent to say what should be done. Next to the weather and the shortage of engineers, engineering curricula is the most talked about subject in professional societies today; and, like the weather, it seems that very few people have done anything about it. Suppose we take a look at some of the current criticisms.

CRITICISMS OF ENGINEERING CURRICULA

The first, a criticism heard a great deal more some 20 years ago than it is today, is that we do not teach enough of the humanities in our engineering education. In a report of the Society for the Promotion of Engineering Education[2] (now the American Society for Engineering Education) 12 years ago, a plan for increasing the breadth of an engineering education was outlined in considerable detail. Today, nearly all engineering educators pay much attention to this segment of the student's education.[3] Under the impetus of the Engineers' Council for Professional Development (ECPD) and other forces, nearly all curricula have been designed so that today they contain at least 20 per cent of material which falls into the cultural stem.

A second criticism concerns the lack of fundamental nature of an engineering education. It seems just as popular today to say that we do not teach fundamentals as it was 20 years ago to say we ignored the humanities. However, no one defined humanities and no one defines very clearly what is meant by fundamentals. Fundamentals to one man are the epitome of specialization to another.

A third criticism, and one which must be separated, for discussion purposes, from the other two, concerns the degree of specialization in engineering curricula. It takes the form that an undergraduate may know all about electricity or single application of electricity but nothing of the associated sciences. These criticisms may be portrayed more clearly by examining a curriculum in some detail. Let us start with the story on the humanities.

HUMANITIES IN ENGINEERING EDUCATION

There may have been a time when the engineer thought he did not have to have social contact with his fellow men and when he could devote his time to his slide rule, his surveyor's instrument, or drawing board. This is no longer true. Thorndike Saville points out that some "50 per cent or more of the engineering graduates sooner or later leave the strictly engineering profession, professional practice of engineering, for careers which may or may not be closely related to engineering as such."[4] However, as the engineers' profession has changed, so has engineering education. Today, nearly all engineering curricula devote a considerable percentage of time to the study of the humanities, see Figure 1. This figure shows the curriculum almost as it has been at The Pennsylvania State College for electrical engineers for the past 20 years. It devotes approximately 20 per cent of the total time to English, history, and other courses in the social humanistic stem. This may not be enough but it is commonly believed to be all we can afford in a 4-year program. It might be possible to do things differently if engineers accepted, once and for all, a process of making engineering training a graduate program similar to that used to produce doctors, lawyers, and dentists, and take 7 years to do it. For the present, it appears that we must live with a 4- or 5-year undergraduate and yet professional curriculum.

There is one other point worth noting When a man graduates from a 4-year course in engineering, none of the enlightened companies feel that the man is fully educated technically and is ready to handle any scientific problem that might be handed to him. Neither does the man have any illusions in this direction. So, he undertakes an intensive program of study to make him a more competent technical man. This may include night-school work taken

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in co-operation with some local university; it may include company courses and, in any event, it involves extensive reading which is accepted as part of the man's professional work. Is this same attitude taken towards the man's social and humanistic development? Unfortunately, many employers wish to include more humanities in the undergraduate training. How many continue, after graduation, to devote 20 per cent or more of their total time to self-improvement in the arts and social humanistic side of life? Why, therefore, if engineers show a deficiency in this side of their characters, can it be blamed on the schools of engineering? If, today, an engineer requires 30 years to reach any degree of technical proficiency; 8 in the grade schools, 4 in high school, 4 in college, and perhaps another 8 as an engineer in training, can one blame his deficiencies in the arts on the 4 years he has in college? True, it might be possible, in college, to ingrain in him a desire to carry on after leaving school, and this we should do.

FUNDAMENTALS, WHAT ARE THEY?

Suppose we consider the second criticism, which usually takes some form of "you should teach them the fundamentals and we will teach applications." One finds it very difficult to establish a definition of a fundamental. I was first conscious of this criticism about 1940, and thought it would be wise to ask representatives of industry to come and clarify the point. Remember, too, that it was difficult to find jobs for engineers in 1940; so I also had in mind that, if we tailored our curriculum to their needs, I could interest employers in our product. This consultation with employers took the form of a conference in which we outlined the electrical engineering curriculum and asked for criticisms. Again and again, we were admonished to give the engineer some culture and to teach him some fundamentals. Finally, almost in exasperation, I asked the most vocal employer just how he defined a fundamental. After a few minutes of confusion, he replied that he could not define it, but he had never yet been able to hire a man who could design the contact slide on a 250-volt 200-ampere switch and he thought that any man who has been graduated from college ought to be able to provide such a design.

The literature shows that there has been some clear thinking on this matter. B. R. Teare, Jr.[5] has stated the problem:

"The noun 'fundamental' has been defined as 'a principle, rule, law, or article which serves as the groundwork of a system' and in the discussions of engineering education (fundamental) is chiefly used in the sense of a general rather than a specialized principle, although it also has the connotation of importance. One primary source of misunderstanding lies in the relative nature of the word. Let me illustrate by an example. In thinking about problems of strain and bending, one may consider four different principles: 1. Hooke's law giving stress in relation to strain; 2. the differential equation for the bending of a uniform beam with any kind of loading and supports; 3. a relation for the deflection of a beam with specific loading and supports; and 4. the relation giving the movement of the free end of a bimetallic thermostat bar of specific shape when the temperature is changed. Of course, these are only four of the many relations that might be considered. They are listed in order of decreasing generality. If one were thinking about the whole field of elasticity he might say that the stress-strain relation is fundamental and the general differential equation is somewhat fundamental although less so than the stress-strain law. He might say that the other two, the equations for bending of a specific beam with a specific support and for the bimetallic thermostat bar, are not fundamental at all. Another person dealing with many similar specific structures or one working exclusively with thermostats might disagree sharply believing that one or both of the last expressions are truly fundamental. In terms of the general definition according to which a principle is fundamental if it serves as the groundwork of a system, either of the points of view mentioned might be justified, because to one man the term system used in the definition means elastic theory; to the other, it is thermostat design. Thus, the word 'fundamental' is necessarily a relative sort of word, and if our manner of dividing responsibilities is to be clarified, the word must be restricted or used in an unambiguous way."

I think this can be summed up in one other sentence, also from Teare: "Thus, one principle is more fundamental than another if it is more general, comprehends more situations, and has wider applicability."

PROBLEMS IN TEACHING FUNDAMENTALS

There are many examples of this generality and fundamentalism. An example met by many students is

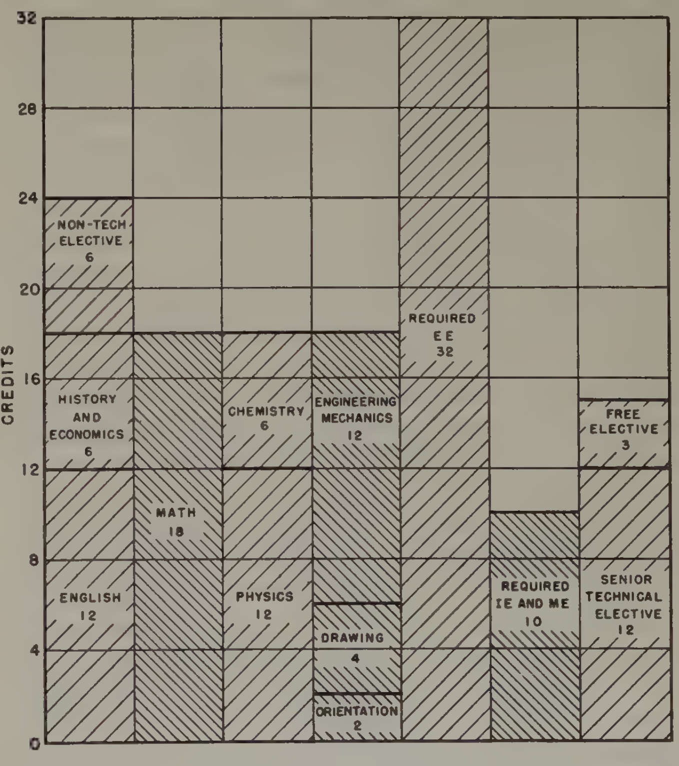

Figure 1. Engineering curricula at The Pennsylvania State College

that of potential which he first learns in a simple physics course, with a particular application to hydrostatics. This example is often used without any concept, at least as far as the student is concerned, of its fundamentalism in describing the potential around an electric circuit and therefore Kirchhoff's Second Law.[6] This example can be extended to the material covered by Olson[7] who builds up a system of generalized analysis based on analogies between electric, lineal mechanical, rotational mechanical, and acoustical systems having a number of degrees of freedom.[8,9] This is a more generalized way of looking at three separate branches of science and certainly, by the test mentioned, is a study of fundamentals. Why, then, do not engineering teachers teach fundamentals or generalities if they all agree this is what should be taught? I think the first reason is that few teachers understand fundamentals in the generalized way. It takes a wise man to have the full scope of science at his fingertips and to realize the universality of some of the concepts he intends to teach.

A second reason is that the student must have some tools with which to reason before he can be taught to reason. One cannot reason in the abstract. One cannot talk about curl H without knowing about a magnetic field and how it is measured. Therefore, a large portion of a student's time must be devoted to learning the concepts and the systems of measurement in which to evaluate reasoned changes. This leads to devoting a considerable portion of time to those aspects of engineering which are later condemned as being practical and therefore not fundamental.

A third factor is that most students do not realize, and cannot be convinced in a few short years, that they gain more by studying fundamentals than by studying more practical things. Unfortunately, nowadays the student himself is making a strong impress on engineering education. This is seen in the growth of course questionnaires and grading systems for professors based on students' ideas of what and how students should be taught. A student's criteria of a good course is often not sound. A student likes to feel that he has accomplished something—that he has learned to design an amplifier, a radio set, and so forth. Or, his measure is that he has gotten an A, or the professor is an amusing lecturer. As a result, one finds that professors who insist on fundamentals and who have the necessary vigor to give time-consuming and rigorous courses on fundamentals are not rated highly by the student audience. Such teachers get a low grade on the student's examination sheet, while teachers of descriptive courses rate high. Thus, the educational process becomes painless and less useful.

Fourth, there is still a considerable demand for students who have an immediate working knowledge of certain phases of engineering. Many of our students enter small companies where knowledge is considered more important than power to reason. Unhappily, most of these smaller companies are unable to give advanced courses of their own, and are too remote from educational centers to provide the proper environment for the complete development of an engineer.

Last, why are not teachers hired who can, and wish to, teach fundamentals? The answer is that we cannot expect too much for the salaries we pay in the teaching profession today. For the past 10 years we have seen our best engineering teachers drawn off into industry to become engineering administrators, research directors, and heads of sections and projects. Nearly every department head and dean today is spending much time trying to convince young men to stay in teaching and thus multiply their contribution to humanity, for say $4,000, when they have been offered much more to enter industry. Not until this situation is corrected will teaching improve.

Many schools have set up curricula with the intention of teaching fundamentals. Nearly all agree on the goal, but agreeing on it is not attaining it. From time to time brave announcements are made of a new plan of action to be undertaken by some school and from then on little more is heard.

This conflict between the ideal and reality is voiced in an ECPD report:[10]

"Although undergraduate programs are slowly progressing to a more thorough scientific basis for engineering practice, they are necessarily and properly limited to fundamental training that cannot possibly reach into new and advanced areas of activity."

And, in another part of the report:

"The undergraduate program is necessarily concerned primarily with the imparting of specific information and procedures (although here, also, there would seem to be the need for a more stimulating approach)."

PROBLEM OF SPECIALIZATION

Now we come to the problem of specialization and this can be considered apart from the problem of teaching fundamentals, but it is not separable from its other result, the lack of understanding of other, more basic topics. It has been my pleasure to hire several hundred young engineers to teach and to do research and development. It has been possible to watch their development and attack on problems which were outside the scope of their 4- or 5-year engineering education. I have been impressed by their lack of understanding of fields of science quite closely allied to their formal branch of the profession. Many young electrical engineers have no concept of and no training in hydro- and aerodynamics. They have little concept of the high degree of analytical and mathematical skill required to solve problems in acoustics and optics. Many think the only nonlinear problem they ever will meet is in magnetism and have no concept of plasticity and the properties of materials when Hooke's Law no longer holds.

Again the question arises as to why these useful concepts are not included in the engineering curriculum. The reason is that instead of taking such work, students are busy specializing on advanced a-c machinery, advanced network analysis, and so forth. They specialize for almost the same reasons which cause us to neglect fundamentals; pressures from employers, pressures from students, and the inability of most engineering teachers to believe that these

studies too can be fundamental to an electrical engineering education. There are some exceptions. For many years, Stevens Institute of Technology, Hoboken, N. J., has offered a single degree in mechanical engineering which covers a broader scope of fundamentals than are common in electrical engineering curricula. Boelter, at University of California, Los Angeles, is making a definite contribution in this direction. Saville, mentioned previously, and Sweigert[11] have published curricula which advocate a broader scientific concept of engineering education.

The problem then arises: If all these factors are recognized, what can one do about it? There are several subsidiary questions which come to mind. The first is just how many 4-year engineering graduates are making full use of their engineering training; how many of them are working as engineering aids or technicians rather than as creative engineers; how many of them could have done just as well with a curtailed engineering course of the technical institute type?[12] If many of them could have been just as successful with a 2-year terminal course, would it not be wiser to give them that course instead of trying to adapt a 4-year engineering curriculum to men who never use the material anyway? Does this not result in a lowering of the academic level of the curriculum; does it not result in a lowering of standards or a lack of rigor? Perhaps the need is to set up fully accredited, perhaps degree-giving, courses which are designed to end with 4 semesters, or 2 years, to train engineering associates instead of making such students take a full 4-year course in engineering.

The second question is whether or not we are doing too little on our 4-year course to prepare a man for graduate work. Are we narrowing the course content to make specialists in our fields of electrical engineering rather than laying out a curriculum on which a man finally may build a specialty to the frontiers of knowledge? Should not some of our course work be laid out with the thought that 4 or 5 years will not end the formal training but will serve merely as preparation for graduate work?

Lastly, cannot we, with our present academic curricula broadened, reduce specialization and increase the rigor of the training?

Can anything be done within a 4-year framework? We find, at The Pennsylvania State College, there are other practical administrative considerations. First, all students are not willing and able to undertake a program of broad generality, rigor, and fundamental nature. The students, for a curriculum of this type, must be the better-than-average students. They must have the ambition found but in a small percentage. Next, not all of the students capable of taking such a curriculum will wish to do so. They may not wish to devote the time; they may not wish the lack of specialization. So, in all probability, such a curriculum will be useful to only 5 per cent of a class.

Second, not all the teachers are capable or willing to teach such material. Therefore, we will have to pick those professors who have the proper qualifications and who wish to devote time to the design of courses and to teaching a fairly narrow intellectual range of students. This will reduce the staff available.

Third, we assume we can sacrifice a certain amount of elective work in the chosen field and that this time can be devoted to contributory courses. Again referring to Figure 1, it is seen that approximately 16 per cent of the student's time is devoted to electives in electrical engineering. This percentage may be given over to courses in those subjects which seem to be invaluable to electrical engineers but which so many of them do not get.

FUTURE FACTORS TO BE CONSIDERED

There are three other factors which are almost self-evident but which ought to be mentioned in a complete analysis of the situation. First, the demand for engineers and technicians is rising and will continue to rise because the economy of our country is expanding and becoming more complex. In short, barring a major depression, the demand for those skilled in science will continue to grow. Second, within a few years we shall pass the dip in the number of college students per year and the large classes which are now in the grade schools will flood our colleges with candidates for admission. Third, under the impetus of rising wages for engineers and the better counseling being done in the high schools because of the efforts of ECPD and other groups, the fraction of qualified students who wish to take engineering also will increase. This means we can expect very large entering classes in the future.

FIT THE CURRICULUM TO THE STUDENTS' NEEDS

Now it is accepted generally that many engineers work far below their skills and many never make use of more than a fraction of their engineering education. Others are not competent to finish a 4-year engineering education unless standards are lowered to permit them to graduate. Therefore, it seems entirely logical to provide an education for such students by establishing a 2-year terminal curriculum for engineering associates or technicians following the principles which already have proved desirable in those curricula already established.[13] This we hope to do at The Pennsylvania State College. There are good reasons why this type of thing should not be given in the same location as the 4-year degree-granting curricula. I believe it is necessary to design the curriculum for the purpose of making engineering assistants only and this will preclude any easy transfer from a 2-year course to a 4-year one. Fortunately, transfer in the opposite direction will be much easier. The major task here, however, is to differentiate between those high-school students who are competent to carry the 4-year curriculum and those who are better fitted to the 2-year schedules.

The second major plan at The Pennsylvania State College is to devise a method of taking care of the more brilliant students. We spend far too much time on the marginal student. For the brilliant student, a curriculum can be devised which will emphasize fundamentals and the engineering sciences. However, if it includes only the top 5 or 10 per cent of the class, all of the courses can be more rigorous and pursued more rapidly and more comprehensively than is possible when the pace of the courses is dictated by the median student. Thus, students in

this group will get a more rigorous and broader education although they may not learn much about applications of science. However, such a curriculum will be aimed at and will definitely fit students to go on to graduate work.

Third, gradual changes can be produced in the ordinary electrical engineering curriculum, allowing more time for the other engineering sciences and decreasing the amount of time available for specialization in what are now called electrical engineering electives. This plan envisages no drastic change in the amount of time devoted to the social and humanitarian studies but will involve some broadening of engineering itself. Thus, with three outlets, one for the engineering assistant, one for the ordinary engineer candidate, and a third for the brilliant student who should pursue graduate work, we will have a system for educating each one of these groups to the best of its ability.

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Dynamic Hysteresis Loop Measuring Equipment

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The dynamic hysteresis loop of a magnetic material is an important factor in determining the amplification and control characteristics of high-gain magnetic amplifiers. The flux density versus the magnetizing force characteristic can be shown as an oscilloscope pattern using the apparatus described herein.

WITHIN THE past 2 or 3 years many scientists and engineers working on research and development projects in the magnetic-amplifier field have come to realize that the dynamic hysteresis loop of a magnetic material plays an important role in determining the amplification and control characteristics of high-gain magnetic amplifiers. Figure 1 shows a block diagram of an excitation and test circuit which has been used often to display the dynamic hysteresis loop of a core material upon the screen of a cathode-ray tube oscilloscope.

This circuit includes means for impressing upon the vertical, or B, axis of the oscilloscope a signal which is proportional to the flux density in the core and impressing upon the horizontal, or H, axis of the oscilloscope a signal which is proportional to the magnetizing force acting on the core specimen under test. The B-axis channel includes a secondary (B) coil wound on the specimen under test, an integrating circuit, and a linear amplifier, the output of which supplies voltage to the vertical deflecting plates. The H-axis channel consists of an amplifier to amplify the relatively low voltage drop across a resistor (current shunt) in series with the primary or exciting (H) coil so as to provide an adequate deflection voltage to the horizontal deflecting plates of the oscilloscope. The Lissajous figure shown by this system on the cathode-ray tube screen then will be indicative of the shape of the dynamic hysteresis loop of the specimen under test.

Figure 2 shows a 60-cycle dynamic hysteresis loop of Deltamax as displayed in the previously described manner by a good system of amplifiers and integrator circuits. Furthermore, by suitable calibrating means, the amplitude of the deflection in the vertical axis will indicate the average flux density in the core and the amplitude of the

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The author acknowledges the contributions of D. R. Kearns and R. Rescorla who carried out the experimental phases of this work.

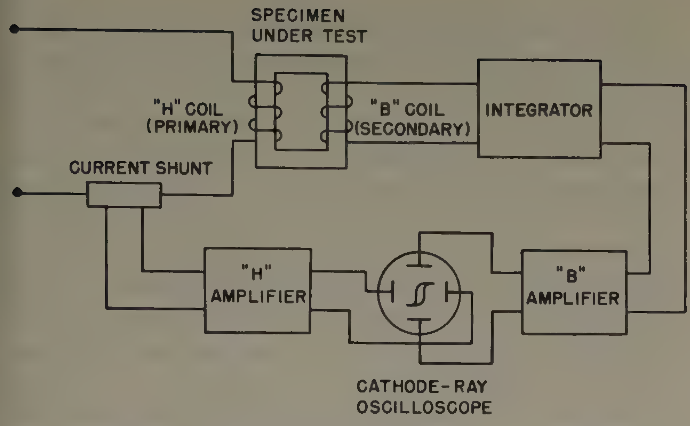

Figure 1. Block diagram of excitation and test circuit

horizontal deflection will indicate the magnetomotive force applied to the core material.

On many occasions the hysteresis loop displayed by such a system has been found to assume some peculiar shapes. At such times one then begins to question the fidelity of the system used to display the dynamic hysteresis loop.

This article will indicate the several sources of errors and their effects upon the displayed hysteresis loop. Also, it will indicate means for compensating for certain errors introduced by the amplifiers and will specify the general performance characteristics of amplifiers which will be satisfactory for displaying a dynamic hysteresis loop without introducing serious errors and/or distortions.

SOURCES OF ERRORS AND THEIR EFFECTS UPON THE DISPLAY

In order to provide a readily reproducible method for testing cores in a manner approximating their use in magnetic amplifiers, a sinusoidal flux wave has been chosen. If the waveform of the average flux density in the core departs materially from that of a sine wave, the maximum rate of change of flux in the core will exceed that of a sine wave. Higher rates of change of flux will produce higher values of indicated dynamic coercive force and, therefore, will be in error. If the total harmonic distortion of the voltage induced by the flux wave is kept to less than 10 per cent, errors due to this effect will be low enough to be tolerable. Figure 3 shows an induced voltage wave with 6 per cent total harmonic distortion due to saturation effects.

The source of power used to excite the specimen under test should be a sine wave with low distortion. It should have a low internal impedance since it must supply highly distorted current waveshapes with only slight distortion of the voltage waveshape of the power source. The resistance of the exciting coil or primary should be kept low.

The current drawn by the exciting coils of the specimen is often highly distorted and may have very high ratios of peak to average values. The resistor used in series with the excitation circuit to act as a current shunt for supplying voltage to the H amplifier must be restricted to relatively low values of resistance. The peak voltage drop across this resistor, plus that across the resistance of the exciting coils, must be only a small fraction of the total voltage applied to the excitation circuit. Excessive nonsinusoidal voltage drops across these resistances will cause the voltage waveform impressed upon the excitation coil to be seriously distorted at peak flux densities which saturate the core.

The B coil, or secondary winding, should be fairly closely inductively coupled to the primary winding. However, care should be taken that the coupling capacitance between this winding and the excitation winding be kept low. This is particularly necessary when testing rectangular-hysteresis-loop core materials, since high-frequency components of voltage are present when testing under conditions of high saturation. Although these high-frequency components of voltage are small, excessive capacity coupling will show up as small oscillations superimposed upon the normal hysteresis loop.

The integrating circuit should have a high impedance in order that the effects of its loading upon the B coil be kept low. Excessive loading by this circuit appears as a widening of the hysteresis loop and therefore is another source of error in determining the true values for the dynamic coercive force and the true shape and area of the dynamic hysteresis loop. The harmonic distortion contributed by the amplifiers should be held to less than 2 per cent. The gain versus signal level should be substantially constant over the operating range.

The H-axis amplifier must be a reasonably broad-band amplifier with low phase-shift response characteristics at the test frequency. Harmonic frequencies present in the

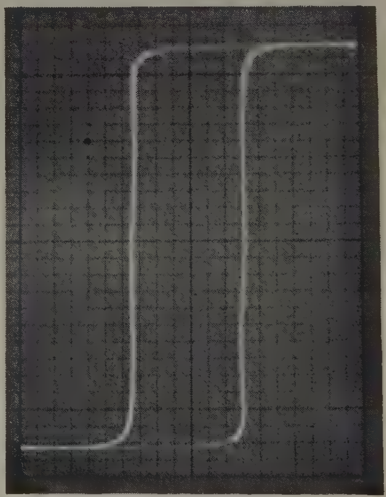

Figure 2. Dynamic hysteresis loop of 0.005-inch Deltamax at 60 cycles

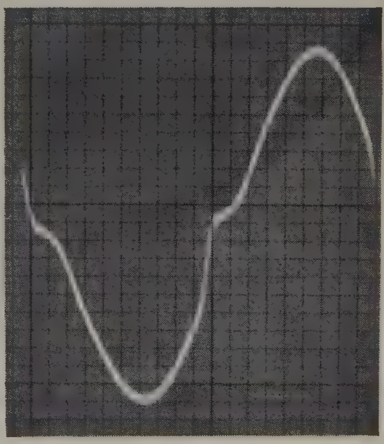

Figure 3. Voltage wave with 6 per cent harmonic distortion

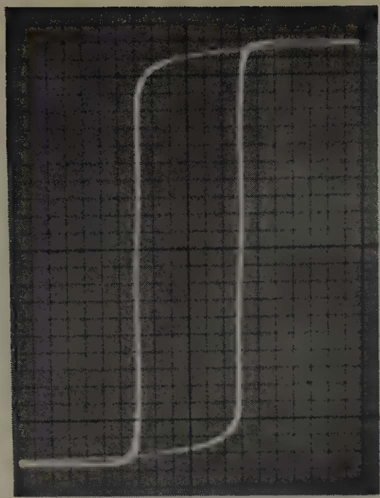

Figure 4. Distortion of loop due to excessive phase lag in "H" amplifier at high frequencies

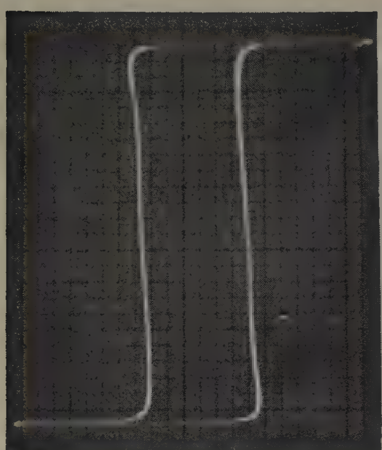

Figure 5. Distortion of loop due to excessive phase lead in "H" amplifier at low frequencies

exciting current may include values as high as the 20th harmonic when testing rectangular hysteresis loop materials. The phase shift of these harmonics must be kept low in order to prevent the portion of the hysteresis loop above the knee of the curve from appearing as shown in Figure 4. The phase shift of the amplifier at the testing frequency and below also should be kept low. Excessive low-frequency phase shift causes distortions as shown in Figure 5.

Care should be taken to assure that this amplifier will not be overloaded by the high peak voltages present in the voltage drop across the *H*-axis dropping resistor when testing to high saturations. The high ratio of peak-to-average of this voltage may overload this amplifier and cause errors in indication of the peak values of *H* under which the specimen is being tested. In some cases, clipping of this voltage is desirable in order to obtain accurate values of the dynamic coercive force under conditions of high peak values of magnetomotive force. However, any such clipping circuits should not affect the calibration or voltage gain of the amplifier within the desired range of linear response.

The voltage-response characteristic of the *B*-axis amplifier at frequencies above the test frequency is of secondary importance. However, the phase-response characteristic at and below test frequency is very important. Excessive low-frequency phase shift (leading phase angle) causes a distortion of the loop of the type shown in Figure 6. Note that this is very similar in appearance to Figure 4 for the case in which the high-frequency phase shift of the *H* amplifier is excessive.

Figure 7 shows the effect of excessive high-frequency phase shift (lagging phase angle) of the combined *B* amplifier and integrator circuit. Note that the effect of this is to widen the loop tip instead of narrowing it or causing a reversed loop effect as shown by Figures 4 and 6.

If the frequency of the power source supplying the amplifier tube filaments and the plate-supply rectifier circuit differs from that of the testing frequency, then hum effects are readily detected by a blurring or widening of the oscillograph trace over the entire figure being displayed by the oscilloscope. However, when the test frequency is synchronous with the source supplying power to the amplifier, the effects of hum in the amplifier are not so readily apparent. Hum effects from the amplifier filaments often cause symmetrical distortion of the hysteresis loop display. Its effect may be either a widening or a narrowing of some portion of the loop. The portion of the loop at which it appears depends upon the phase of the hum with respect to the excitation voltage. This type of hum effect usually can be detected by reversing the phase of the voltage applied to the excitation circuit and noting any change in the shape of the displayed figure.

Hum due to insufficient filtering of the plate supply to the amplifier has a predominant second-harmonic component. This causes an asymmetrical distortion of the hysteresis loop and is evidenced by a reduced deflection in one portion of the loop and increased deflection in the corresponding portion of the other half of the loop.

CRITERIA FOR MAXIMUM TOLERABLE ERRORS

In order to specify the minimum performance requirements of measuring equipment such as this, it is necessary to set up some criteria upon which to judge whether or not the equipment is satisfactory. Criteria chosen for this dynamic hysteresis loop measuring equipment are:

All amplitude or deflection distortion effects were judged as being satisfactorily low if the error they introduced was less than 5 per cent of the indicated value or less than one trace-width, whichever is greater.

The phase distortion was considered unsatisfactory if

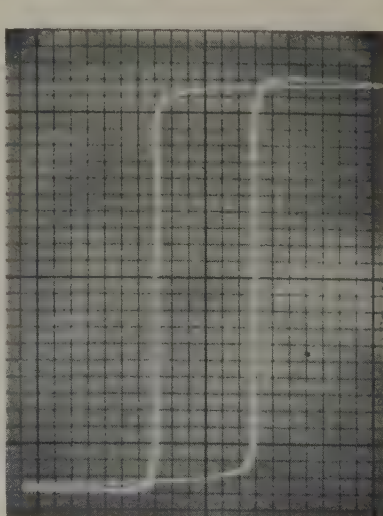

Figure 6. Distortion of loop due to excessive phase lead in "B" amplifier at low frequencies

it was detectable by a close observation of the displayed figure shape. In many cases this amounted to a change corresponding to approximately the width of the oscillograph trace. A rectangular hysteresis loop material was used as the specimen under test when judging phase-distortion effects upon the measuring circuit performance. This imposes severe requirements upon both the B and H channels. The H amplifier must handle a very wide frequency range and a phase distortion in the B amplifier is readily detected by a widening or a reverse looping of the trace above the knee of the hysteresis loop.

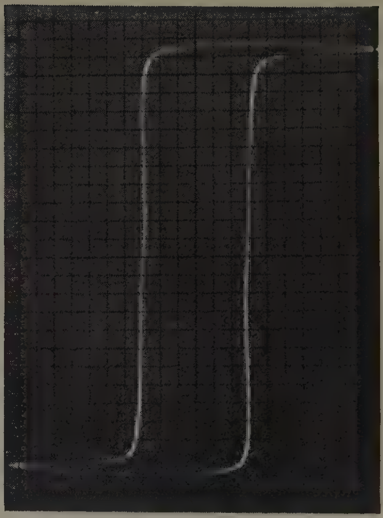

Figure 7. Distortion of loop due to excessive phase lag in "B" amplifier plus integrator at high frequencies

CHARACTERISTICS OF AMPLIFIERS OF MINIMUM PERFORMANCE

THE MINIMUM performance characteristics required to meet the foregoing criteria now will be indicated. Each amplifier is assumed to be a 3-stage amplifier and is specified upon the basis that a good wide-band amplifier is used for the other axis. Somewhat poorer phase response characteristics could be tolerated if both amplifiers were identical and had a constant time delay. However, this possibility has been ignored in arriving at the requirements given here.

In order to keep the phase shift to a satisfactorily low value, each stage of the H-axis amplifier should have less than 45 degrees of phase shift at a low frequency of 1/100 of test frequency and at a high frequency of 250 times test frequency. With conventional types of resistance-capacitance coupling networks and with screen and cathode circuits such that they do not contribute to the frequency-response characteristics, the amplitude response per stage will be down 3 decibels at these indicated frequencies.

The requirements for the B-amplifier phase shift is very stringent on low-frequency response and a little less stringent than that of the H amplifier on the high-frequency end. If a single resistance-capacitance integrating circuit having a phase angle at operating frequency of 89.75 to 90 degrees is used, then the low-frequency phase response per amplifier stage must have a phase shift of less than 45 degrees at 1/300 of the operating frequency. However, if suitable compensation is provided by an additional corrective integrating network per amplifier stage, then the low-frequency phase response need be only less than 45 degrees at 1/30 of the operating frequency.

The high-frequency phase response of this B amplifier should be such as to have less than 45 degrees of phase shift in each stage at 100 times operating frequency.

With a suitable broad-band B amplifier, a simple single resistance-capacitive network of proper values will provide satisfactory integration. It should be such as to provide, across the capacitor, a voltage which lags the input voltage by 89.75 to 90 degrees at operating frequency.

When additional integrating type of resistance-capacitive networks are added to equalize for excessive low-frequency phase advance or lead due to the coupling networks in the amplifier, the equalizing networks should be such as to provide, at operating frequency, a total over-all lagging phase of 90 degrees$\pm$0.25 degrees for the combined integrator and entire B axis amplifier circuit.

The maximum distortion in the voltage wave induced by the flux wave should not exceed 10 per cent. This includes distortion due to the power source and all series resistance in the excitation circuit.

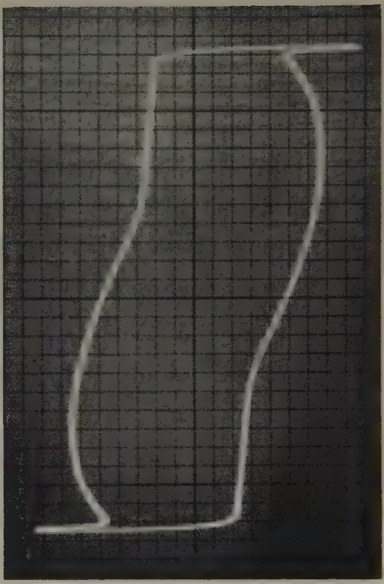

Figure 8. Dynamic hysteresis loop of 0.010-inch Deltamax at 400 cycles

As a final check for a complete system of these minimum performance specifications, networks representing this complete amplifier system were inserted between a test specimen and a broad-band oscilloscope. The loop displayed by this system was photographed and compared with photographs of the loop displayed when using a 90-degree integrator network and just the broad-band oscilloscope. The dynamic hysteresis loop displayed by the complete system met the original criteria set forth when, at test frequency, the integrator circuit was adjusted so that the phase of the output voltage of the B amplifier lagged the phase of the output voltage of the H amplifier by no less than 90 degrees nor more than 90.5 degrees.

The amplifier performance specified in this article is admittedly somewhat conservative. However, when one employs amplifiers meeting these specifications, along with carefully applied instrumentation, and obtains a dynamic hysteresis loop such as that shown by Figure 8, it is safe to assume that the displayed Lissajous figure truly represents the dynamic hysteresis loop of the specimen under the conditions imposed by the test circuit.

Load Current Representation of a D-C Machine

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FOR SOME TIME the interpole winding on d-c machines has been used to provide a signal for control circuits. The voltage drop across the interpole winding resistance can be used as a practical indication of large values of load current. However, for machine operation producing rapid changes in load current, the voltage across the interpole winding fails to remain proportional to load current. The purpose of this article is to present a system that will represent the load current for transient as well as for steady-state operation.

The solution consists of placing a second winding on the interpole magnetic circuit. When the original and this corrective winding are connected properly in series, the voltage across them will be equal to the voltage drop of the original winding resistance. There must be equal voltages induced in both windings. To insure this, the following test method was used: an alternating voltage was applied to both the original interpole winding and the horizontal plates of a cathode-ray oscillograph. The voltage across the two interpole windings in series was applied to the vertical plates of the oscillograph. Thus, when the resulting line on the oscillograph became horizontal, the desired number of corrective turns would have been wound. Both horizontal and vertical amplitude settings were adjusted to give equal deflections for the same voltage applied and then were left in position. The point of zero vertical deflection occurs at slightly different numbers of turns for different frequencies. Therefore, it is important to use a frequency within the range of frequencies encountered in normal operation. In this article, 60 cycles was used as indicative of the range of roughly 20 to 500 cycles.

The voltages induced in the original interpole winding were five in number. These were: 1. a voltage of self-inductance; 2. a voltage of mutual-inductance from the armature winding; 3. a voltage of mutual-inductance from the rectifier-excited main field; 4. a voltage caused by slot flux pulsation; and 5. a voltage caused by flux pulsation because the armature is not a true cylinder. An equation showing the total instantaneous voltage across the original interpole winding is presented below:

$$e_I = i_a R_0 + \underbrace{L_0 \frac{di_a}{dt}}_{(1)} - \underbrace{m_{a0} \frac{di_a}{dt}}_{(2)} + \underbrace{m_{f0} \frac{di_f}{dt}}_{(3)} + \underbrace{N_0 \frac{d\phi_s}{dt}}_{(4)} + \underbrace{N_0 \frac{d\phi_a}{dt}}_{(5)}$$

The effects of these induced voltages for steady-state operation were eliminated by the corrective interpole winding. Also for transient operation, it was found that the corrective interpole winding performed extremely well. The transient conditions investigated were: 1. sudden opening and then closing of the load circuit with a resistive load on the generator; 2. the same as 1 with a motor load on the generator; 3. short circuit of the generator by a circuit breaker; 4. sudden increase and then decrease of resistance in the main field with a resistive load on the generator; and 5. the same as 4 with a motor load on the generator. The two oscillograms shown represent condition 3, the severest condition possible. They indicate the effective elimination of the induced voltages by the corrective interpole winding.

The following procedure is believed to be the most effective in the actual construction of this system. The most desirable time to wind the corrective turns is with the original interpole winding during machine construction. If this is not possible, proceed as follows:

1. Use the test method to determine the proper direction in which to wind the corrective winding. If the readings do not decrease in magnitude as turns are wound, the turns should be wound in the opposite direction.

2. Use the test method to determine the necessary number of corrective interpole turns. To determine the necessary number, it is not required to actually wind all the turns. After a few turns have been wound, points can be plotted of vertical deflection versus number of corrective turns, and the curve can be extended in a straight line to the zero deflection line. If a cathode-ray oscillograph is not available, two voltmeters could be used in this test method.

3. Knowing approximately the necessary number of corrective turns, determine the maximum wire size that can be used to put this number of turns in the limited space. In this way, the best mechanical wire strength is obtained.

4. With the wire size determined, wind the necessary corrective interpole turns with this wire. Take occasional readings for the test method as a check. If it proves necessary to remove the armature to do the winding, be sure to replace the armature for the test.

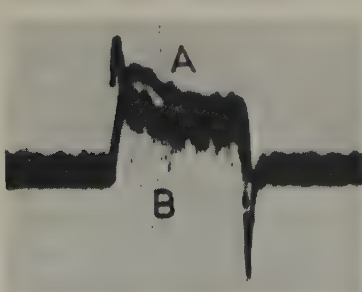

Figure 1. Generator without corrective turns short-circuited by circuit breaker. A is the load current, B the interpole voltage, and duration of current pulse is 0.0875 second

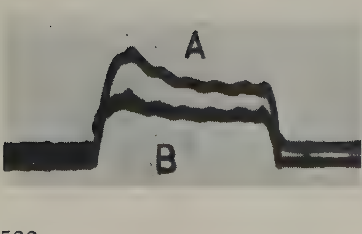

Figure 2. Generator with corrective turns short-circuited by circuit breaker. A is the load current, B the interpole voltage, and duration of current pulse is 0.119 second

Digest of paper 52-70, "A Simple, Effective Method of Representing the Load Current of a D-C Machine," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Not scheduled for publication in AIEE *Transactions*.

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New Series-Type Trolley Coach Motor

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This new motor for trolley coaches combines the advantages of the series motor in acceleration and the shunt generator in dynamic braking. Among the many improved electrical and mechanical features is superior commutation in both acceleration and braking.

THE TROLLEY COACH has become established as one of the most important vehicles in city transit. On December 31, 1940, there were only 2,802 trolley coaches in the United States. At the end of 1950, the latest date for which accurate data are available, there were 6,504, an increase of 132 per cent. The position of electrically propelled vehicles in the city transit field is largely dependent on the trolley coach because in the 10-year period the number of surface cars has decreased from 26,630 to 13,800, while the number of subway and elevated cars has decreased slightly. This latter decrease is caused by the scrapping of a number of old elevated cars, the total rapid-transit passengers and car miles operated remaining essentially the same. In the 10-year period the number of motor busses increased from 35,000 to 56,820, or 62 per cent.

The rate of trolley coach growth was retarded during the war by the shortage of copper. From the standpoint of financial results, the trolley coach is unrivaled in the transit field. The net income from trolley coach operations in the United States, after all taxes, has been more than $10,000,000 in each of the last 3 years. City bus operations have had losses of $3,000,000 to $13,000,000 per year in the same period. In many cities having streetcars, trolley coaches, and busses, only the trolley coaches are operating at a profit. Aside from the more economical operation of trolley coaches, they have marked advantages in comfort, quietness, high schedule speeds, and freedom from odors. The principal deterrent to their use is the necessary investment for overhead lines. The financial status of many transit companies is such that the initial investment required, and not long-range economy, is a determining factor in purchases.

Under present conditions, the trolley coach has proved to be the most economical vehicle for the heavier lines in small and medium size cities, as well as for a high percentage of the surface routes in the larger cities including rapid-transit feeder lines. In view of the trolley coach's position as the potential successor to the streetcar as the principal electrically propelled vehicle in city transit, it is imperative that its electric equipment be outstanding in reliability and low maintenance. The new motor described in this article and the new control described in another paper[1] have been designed to meet these objectives.

SERVICE REQUIREMENTS

THE MODERN TROLLEY coach has a seating capacity of 44 to 50 passengers. Its weight varies from 17,000 to 21,000 pounds. The dual rear wheels are driven through double reduction hypoid and spur gears generally having a total reduction of 11.58 to 1. The rear tires have a rolling radius under load of 21.5 inches. The motor must be able to accelerate the coach with average load at a maximum rate of 4 miles per hour per second. The normal rate of dynamic braking is 2 miles per hour per second. The motor armature and commutator must not be damaged by maximum coach speeds of 50 miles per hour. Balancing or free running speed on level roadway with full line voltage applied should be close to 40 miles per hour. The motor design must be such that commutation is successful both when propelling the coach and during dynamic braking, especially from high coach speeds.

The motor ratings and characteristics have to be suitable for the frequent-stop highly congested service met in cities like Boston and Providence, the high schedule speeds required in Cleveland and Chicago, and the severe grades approaching 20 per cent in San Francisco and Seattle. Only by standardization on one motor for the varied conditions of operation can the cost be held to a reasonable value, although the motor speed and rating, or both, may be higher than required for some applications.

DESIGN OBJECTIVES

THE SERIES-TYPE traction motor, without question, provides the most desirable speed and torque performance for transportation vehicles. However, the series motor is difficult to control for dynamic braking and leaves something to be desired as far as smoothness of braking is concerned. Paralleling the development of trolley coaches, the desire has increased for smooth dynamic braking performance as well as for a reduction in the complexity of the control and in the duty imposed upon its working parts. These requirements can best be met by co-ordinating the designs of the control and the traction motor. Thus, the type *1442-N1* motor has been designed to complement the new, greatly simplified trolley coach control. The design of the new trolley coach motor has been based on two principal objectives:

1. A motor having the same good accelerating per-

Full text of paper **52-37**, "New Series Motor for Trolley Coaches," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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formance as the previous type *1442-A* series motor including comparable flashing resistance.

2. A motor providing a smooth and essentially constant rate of dynamic braking without requiring control notching as in the case with the series type of machine.

These aims have been met with the type *1442-N1* traction motor, shown in Figure 1, which has the same mounting dimensions as the earlier series motor. This motor has a 1-hour rating of 140 horsepower, 194 amperes, 1,700 rpm, at 600 volts self-ventilated.

The desirable motoring performance shown in Figure 2 is obtained by use of the series field only, thus retaining the inherent stability against flashing that is characteristic of the series-type motor.

Smooth, notchless, and almost constant dynamic braking effort is provided over a wide speed range, as shown in Figure 3, by adding a shunt field winding which is used with a differential control circuit. The extra space required by the shunt winding has been obtained by increasing the frame diameter by $1^1/_2$ inches. Figure 4 shows the circuit employed to accomplish this automatic braking performance. Both the shunt field current which is supplied from the line and the current generated by the armature must pass through the braking resistor R_b. At high vehicle speeds, the armature current is large and produces a large voltage across the braking resistor, thus reducing the voltage available across the shunt fields which decreases the shunt field current and limits the generator torque. Conversely, at low speeds, the armature current and braking resistor voltage are small, thereby increasing the shunt field excitation and essentially maintaining constant torque.

MECHANICAL DESIGN FEATURES

The long section of the new "Super-Series" motor, Figure 5, shows many of the important mechanical features that have been incorporated in its design.

Mechanically, the design centers around the integral frame construction with its welded-on commutator-end housing. This type of construction assures correct bearing and brushholder alignments since the commutator-end housing is machined as part of the frame, and being permanently attached, this alignment will not be altered.

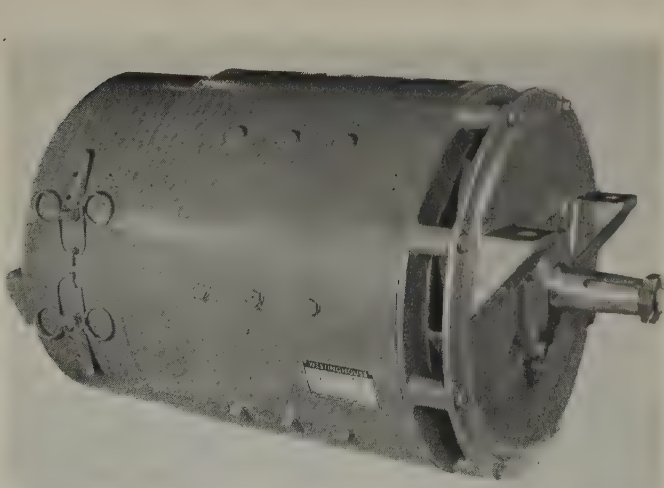

Figure 1. The new trolley coach motor, type 1442-N1, 140 horsepower, 600 volts, 1,700 rpm

The brushholders are the so-called end-mounted type and are clamped in blocks that are welded to the machined inside face of the frame. The integral-type frame construction makes possible the precise location of these brushholder blocks by means of a fixture that locates directly from the commutating pole bolt holes.

The brushholders are precision cast by the permanent mold process which results in accuracy and uniformity. The spring saddle and tension key construction provides for easy brush pressure adjustment. A factor of value to transit maintenance departments is that all four brush-

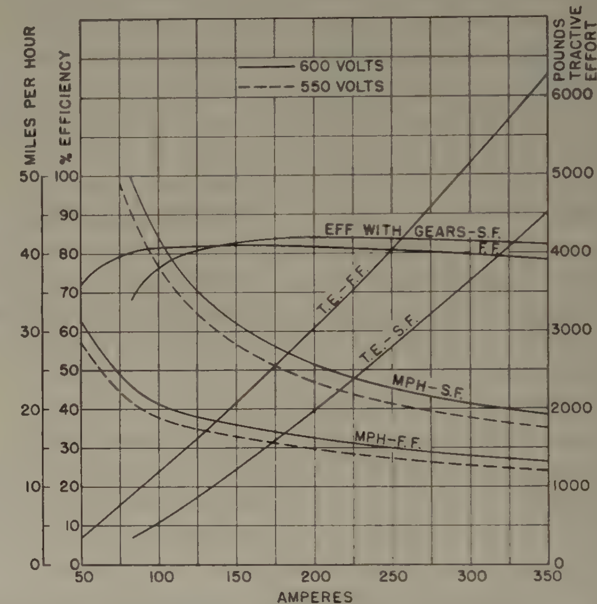

Figure 2. Characteristic curves of type 1442-N1 motor. 600 volts, 11.58 to 1 gear ratio, 43-inch wheels

holders are exactly the same, thereby requiring only one item for stock.

An "all-out effort" has been made to provide an exactness of brush position that will be permanent. In addition to the afore-mentioned steps that have been taken to assure accurate components, there is an inherent advantage to the end-mounted brushholder. It will be noted that the clamping action on the brushholder pins is only slightly farther from the center of the armature shaft than is the contact of the brushes with the commutator. As a result, a slight tilting of the brushholder pins in the mounting block grooves will produce negligible movement of the brush position, thereby maintaining good brush spacing. This is a distinct advantage over the conventional side-mounted holder where the clamping action takes place a great distance from the brush contact with the commutator.

Another feature of considerable importance from the maintenance standpoint is found in the drive-end housing and bearing assembly construction. The drive-end bearing assembly has been redesigned to permit the removal of the housing and even the armature fan without requiring that the bearing inner race and rotating grease throwers be pulled from the armature shaft. This has been accom-

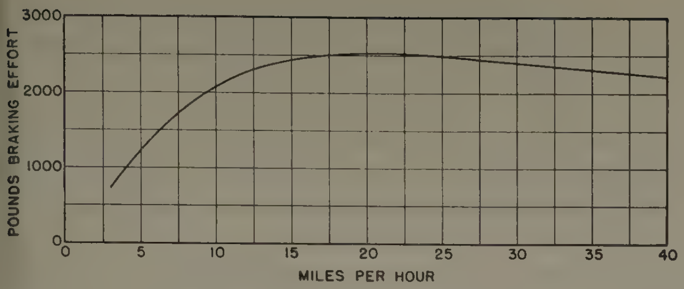

Figure 3. Dynamic braking curve of type 1442-N1 motor, 11.58 to 1 gear ratio, 43-inch wheels

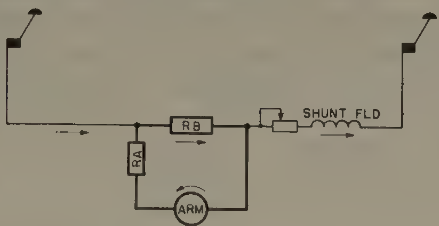

Figure 4. Schematic of the dynamic braking circuit

plished without sacrificing the effectiveness of the labyrinth seals which have been proved to be so effective.

Years of experience gained from operation of earlier trolley coach equipments has pointed out several minor mechanical changes that were desirable. These modifications, as well as applicable developments in materials and processes that have occurred in the meantime, have been incorporated in the design of the Super-Series motor. Some of these items are worthy of mention in that they are related to improved performance, accessibility, or convenience, or directly to reduced maintenance labor.

1. Machined commutator cover seat for tight fit of covers.

2. Reversible commutator covers permitting latches to be located on either side of the motor.

3. End-mounted brushholders providing accessibility in the commutator compartment that is impossible with the side-mounted type of holders.

4. Full reaction type brushes for best commutator riding qualities.

5. Synthetic bonded bar and V-ring mica adopted for the commutator, increasing its strength and stability at higher temperatures.

6. High melting point solder adopted for soldering armature conductors in the commutator risers and for the armature bands.

7. Flash ring added to the commutator-end bearing cartridge to protect the bearings against damage from flashing current.

8. Brushholder cross connections relocated in the wiring-around-frame on the field coil side to provide full access to the commutator V-ring string band for cleaning and painting.

9. Through bolts used to fasten the drive-end housing to the frame, making possible the use of a socket or spinner type wrench.

ELECTRICAL DESIGN FEATURES

THE PRINCIPAL ELECTRICAL change was made necessary by the addition of the shunt field winding for dynamic braking purposes. The main field coil which contains both the series and the shunt windings is of unitized construction.. The series winding is wound from large rugged copper strap which is then insulated over-all as a unit. The shunt section is wound with a sufficiently large round wire to permit winding in "turns and layers" so that each wire is in its proper position, thus avoiding laps and cross-overs and the possibility of short circuits developing between turns. The shunt section also is completely insulated as a unit and is then assembled with the series coil and the entire coil is taped over-all, resulting in a single mummified main field coil unit.

Both the main and commutating field coils have been insulated with Silastic tape which is a silicone-rubber-impregnated glass tape. Silastic tape is a fully class-*H* insulating material, but due to its rubber-like characteristics it has other desirable properties. It provides an excellent seal against creepage due to the presence of oil or water since it has considerable flexibility in taping and the Silastic has a tendency to vulcanize between layers during baking in a manner similar to rubber. Silastic insulation also will have exceptionally long life when used within normal class-*B* temperature rises as have been maintained in this design.

Two improvements have been made in the armature winding, which, incidentally, will not affect its interchangeability with the earlier series-type motors.

1. The armature conductors have been changed to have double-glass insulation which represents a considerable improvement over the previously used conductor insulations

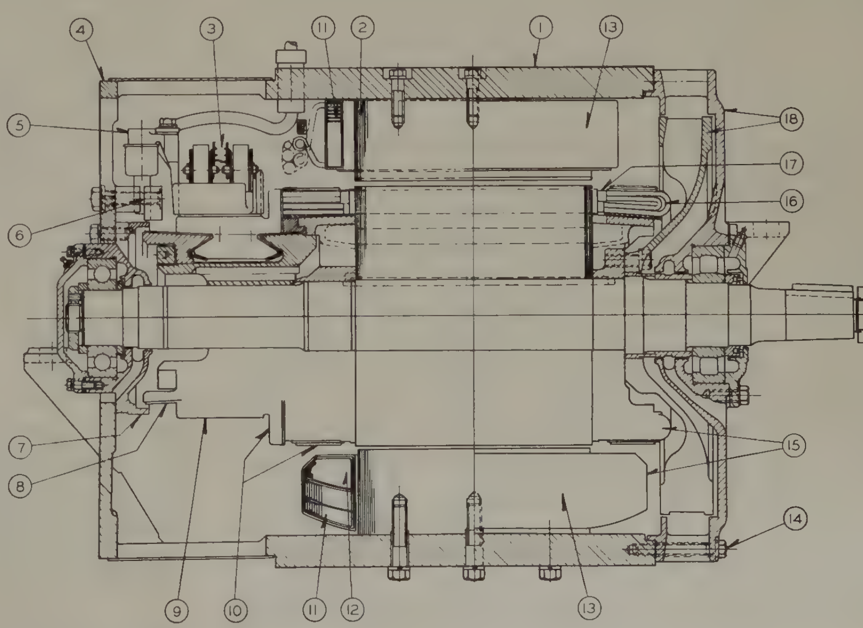

Figure 5. Longitudinal section of type 1442-N1 motor

consisting of either asbestos or enamel-asbestos. The glass insulation is nonhydroscopic in nature and great strides have been made in its application to the wire to the extent that the wire can be bent around a normal forming pin without cracking or peeling as is common with asbestos-insulated wire.

2. The wrapper ends have been sealed well onto the diamond portion of the coil with Teflon tape. Teflon is a valuable new class-H insulating material derived from the fluorocarbon family that has dielectric strength even higher than that of mica, but, in addition, has the advantage of having a considerable amount of flexibility. It is this latter quality that makes Teflon so valuable as a wrapper sealer since it tapes smoothly around the bend of the coil without exhibiting the voids that make mica tape so susceptible to creepage breakdown.

Both armature and field windings, in addition to the normal varnish treatments, receive a spray coat of red insulating enamel. The enamel produces a hard slick surface that is effective in shedding moisture and also resists the tendency for dirt to accumulate.

RESISTANCE TO FLASHING

Since the trolley coach receives its power from an overhead line, the traction motor is subjected to voltage interruptions and surges that are conducive to flashing at the commutator. The straight series motor was unexcelled with regards to its resistance to flashover, and in the design of the Super-Series motor, the utmost has been done to maintain this good flashing characteristic.

However, the addition of the shunt field winding has a deleterious effect upon the resistance of the motor to flashing. If the shunt winding could be left open during motoring, it would have no effect upon the series motor performance. However, since the shunt winding encompasses the main field pole, it is coupled by mutual inductance to the series field winding. Thus, whenever there is an interruption or surge of current in the motor circuit that causes a change in the main pole flux, a voltage is induced in the shunt coils. Since there are a large number of turns in the shunt winding, the induced voltage would be of a magnitude that would exceed the safe dielectric limits of the coil insulation. The remedy for this excessive induced voltage is simple, but it is not accomplished without a price. A field discharge resistor is connected across the shunt field leads so that, during the surge, it permits current to flow in the shunt coil. This current produces ampere-turns in the shunt winding that oppose the build-up or decay of flux in the main pole and since the induced voltage is proportional to the rate of change of the flux, it thereby is reduced to a safe value as predetermined by the resistance of the discharge resistor. However, this action in reducing the rate of change of the motor flux constitutes additional damping action and reduces the ability of the motor to withstand power interruptions.

In the design of the Super-Series motor, the loss in flashing resistance resulting from shunt field damping action has been offset by the development of laminated commutating poles. Interruption tests taken with the Super-Series motor confirm that its ability to withstand power interruptions or surges is essentially the same as for the older series motor.

CONCLUSION

Listed here are the most important design features of this motor (refer to Figure 5):

1. Rigid 1-piece frame and commutator housing.
2. Laminated commutating poles.
3. Easy brush tension adjustment.
4. Machined commutator cover fit.
5. Precision "permanent mold" brushholders.
6. Accurate brushholder mounting.
7. Flash ring protection.
8. Full access to string band.
9. Synthetic bonded mica for stable commutator.
10. High melting point solder.
11. Heavy strap for series and commutating pole windings.
12. Large glass-insulated wire for shunt winding.
13. Silastic-tape field coil insulation.
14. Accessible housing bolts.
15. Smooth enamel finish on windings.
16. Glass-insulated armature conductors.
17. Wrapper ends sealed with Teflon tape.
18. Housing and armature fan removable without pulling bearing assembly from shaft.

Five sample trolley coach equipments of this type have been in service in Boston and Chicago since the autumn of 1950. Their performance from the standpoint of the coach operators has been most successful. Experience shows that the objectives of the design have been met. The motor commutator surfaces are clean and have an excellent polish, confirming that the good commutating characteristics of the series motor have been retained.

REFERENCE

1. A New Control for Trolley Coaches, **N. H. Willby.** AIEE *Transactions*, volume 71, 1952 (*Proceedings T2-38*).

AEC Releases 23 Patents to Public

Descriptions of 23 patents owned by the United States Government and held by the Atomic Energy Commission (AEC) have been transmitted to the United States Patent Office for registry and listing. The AEC will grant nonexclusive royalty-free licenses on the patents as part of its program to make nonsecret technological information available for use by industry. AEC-held patents and patent applications released for licensing now total 395. The list of patents giving number, title, inventor, and abstract may be obtained from the Atomic Energy Commission, Washington 25, D. C. Applicants for licenses should apply to the Chief, Patent Branch, Office of the General Counsel, United States Atomic Energy Commission, Washington 25, D. C., identifying the subject matter by patent number and title.

European Electrical Safety Requirements

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Standardization and safety testing of electric equipment is always an important problem. This article briefly surveys the situation in Europe. Although each country has its own program, the International Commission on Rules for the Approval of Electrical Equipment (CEE) makes recommendations to its 13 member nations.

THE ELECTRICAL safety regulations of the various European countries naturally are influenced greatly by the characteristics of the power supply systems, the climate, the building constructions, the materials available, and the habits of the people.

Electric power supply varies from small isolated plants in villages to large interconnected systems. This article will discuss only the lighting, appliance, and small commercial and industrial uses of power. The amount of direct current used for these purposes varies among the countries, but there still are many communities supplied with it, some at 110 volts and many at 220 volts, 2 or 3 wire. Alternating-current supply voltages reported are 105, 110, 115, 120, 125, 127, 130, 145, 160, 210, 220, 240, 250, 276, 380, and 415. Frequencies reported are 25, 40, 42, 43, 45, 50, 76, and 100. There are single phase, both 2 wire and 3 wire, 3 phase, and 3 phase 4 wire with grounded neutral.

The trend of standardization is toward two standard distribution circuits, namely 220/380 volt, 3 phase, 4 wire with grounded neutral; and 127/220 volt, 3 phase, 4 wire with grounded neutral. The proposed standard frequency for all countries is 50 cycles. One important country has recently decided to work toward 240/415 volts at the customer's meter as the standard. Because some of the largest cities and many towns and villages in some of the countries always have been supplied at a voltage between 100 and 125 for lighting, appliance, and commercial uses and the change to a 220-volt supply would involve enormous cost to the users, it is expected that 127/220-volt distribution will be the standard in those areas.

Because it is probable that a considerable portion of the production of any appliance or other equipment will be sold for use on a circuit rated as much as 415 volts and a voltage to ground of 240 volts, the safety testing specifications are based on that assumption.

The climates vary from arctic to mild temperate, and from very humid to very dry. In very few places is there adequate and continuous heating of the interior spaces in buildings during cold weather. Since buildings are commonly constructed of masonry with cement, terrazzo, or stone floors, and often with dirt floors in some places, the conductivity of the floors and walls must be considered when planning insulation or grounding to reduce the risk of electric shock.

Since wood frame construction is not used much, except in some of the countries far to the north, there is not much fire hazard except to the contents of buildings, such as furniture, draperies, and so forth.

Because of the prevalence of utilization circuits of 220 volts and more to ground, a great deal of attention has been given to the subject of grounding the exposed metallic surfaces of all equipment. Grounding is for the purpose of preventing a dangerous voltage from appearing on the exposed metallic part in case of a failure of the electrical insulation within the equipment. In general, the intent of the regulations is to limit this voltage to less than 50 volts by proper selection of grounding method and to limit its duration to less than 5 seconds by proper selection and co-ordination of the overcurrent protective devices in the circuit.

In all countries, grounding by a separate grounding conductor to a water pipe or to a made electrode is permitted. In most countries, the use of an "earth leakage relay" in that grounding conductor is permitted, but with certain requirements regarding maintenance in good working condition. In some countries, considerable use is made of the grounded neutral of the supply system as the grounding conductor for equipment.

Fixed equipment, including heating and cooking appliances in the home, usually is required to be grounded. Portable appliances used in dry locations with insulating or nonconductive floors are not required to be grounded if the supply circuit is not over 250 volts to ground. Even if the space is dry but the floor slightly conductive and the voltage to ground is not over 125 volts, no grounding is required.

Because grounding of exposed metallic parts of portable appliances is always difficult to accomplish, the use of "extra-strong" insulation or "double" insulation is recommended for those appliances which might be used where the floor or surroundings might be conductive. Double insulation means placing insulation between the mounting brackets and frames of the components and the casing or enclosure. For example, in a clothes washing machine, the motor would be insulated from the frame of the washer at the mounting brackets and by an insulating section or coupling in the shaft and the switch bracket and cord mountings or bushings likewise would be insulated from the frame.

Some of the tests applied to electric heating and cooking

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appliances may be of interest as examples of the requirements for safety of fixed and portable appliances in common use on circuits having 220 volts to ground in Europe.

The insulation breakdown test is 1,500 volts. This is applied while the appliance is supplied with its rated voltage from an isolating transformer and the appliance is in the condition as received from the submitter. After it is subjected to exposure to a humid atmosphere in a special chamber for 8 or more hours, it is again tested with 1,500 volts but not energized.

Leakage currents are carefully measured after the same process of humidification. For portable appliances the desired maximum leakage current on 220 volts is 0.5 milliampere although this is recognized as about the threshold of susceptibility for most people and a greater value might be considered safe. For the larger types of fixed cooking and heating appliances somewhat higher values seem to be acceptable, especially since most such appliances must be grounded. Leakage currents seem to be the subject of a great deal of study and discussion.

Creepage distances and clearances are specified in considerable detail. Here are some examples:

	Creepage in Millimeters
Over ceramic materials	2
Over other insulating materials	3
Between live parts countersunk on the outside and a metal surface	6
All other creepage distances	4
Between live parts of different polarity	3
Between live parts and accessible metal parts or unlined metal covers	2
Between countersunk parts and metal	6
Between all other live parts and noncurrent carrying parts	4

Tests are made on all insulating materials to determine the resistance to pressure. Two standard methods are employed. In one method, the sample is placed in an oven and a small metal ball is pressed against the surface to see if it has softened under heat. In the other method, a hole is drilled in the sample, a heated tapered mandrel pushed into the hole to determine the degree of softening or flowing, and a spark is played across the surface near the mandrel to ignite any gas that might be given off due to decomposition under heat.

Tests for mechanical strength of components and of the complete structure depend upon the character of the product. Durability tests are run on switches, thermostats, and all operating mechanisms.

Heating tests are conducted under actual load conditions, if possible, otherwise on some form of standard load and at an input somewhat higher than normal rated input. Voltage swings on many circuits are quite large and an appliance might be in use when the voltage was at its peak.

Generally the maximum permissible rise in temperature of the surface on which an appliance might rest is 60 degrees centigrade. The maximum temperature rise of terminal pins for plug connections, if not over 6 amperes rating, is 40 degrees centigrade. For metal handles it is 30 degrees centigrade, for wood or molded material handles it is 50 degrees centigrade.

All heating tests are to be conducted in an ambient temperature of 20 degrees centigrade ± 5 degrees.

In all locations where there is exposure to conductive surfaces or objects, and the user of the appliance may be in close contact with such surface or objects, such as inside a steel tank, it is strongly recommended that a low-voltage appliance, tool, or lamp be used which is supplied at not over 24 volts to ground or 42 volts between conductors from an isolating step-down transformer.

Space does not permit a detailed explanation of all the requirements and of the tests for compliance in the various countries, but the preceding comments will give some idea of the attention being given to the problem.

Every country in Europe has a program of standardization and safety testing of some kind, and many of them have excellent laboratories for the purpose. The International Commission on Rules for the Approval of Electrical Equipment (CEE) is composed of representatives of the proper organizations in 13 countries, and is very actively engaged in developing specifications to be recommended to the individual countries for enforcement by their own inspection authorities. The Office for European Economic Co-operation (the Marshall Plan) has recognized this activity as contributing to the lowering of trade barriers among the European countries. A few CEE Specifications have been published and several others are soon to appear in printed form. More detailed information and copies of their specifications may be obtained through J. W. McNair, at the American Standards Association, 70 East 45th Street, New York 17, N. Y., or from the secretary of CEE, Professor G. deZoeten, KEMA Laboratories, Utrechtsweg 210, Arnhem, Holland.

There is a tremendous interest on the part of the consuming public in electric cooking and heating appliances and in all the motor-operated labor-saving appliances for the home. The importance of safety standards for such equipment has been recognized in all the countries. American practices are studied with a great deal of interest and the American products that comply with the European safety requirements are highly regarded.

Fluorescent Lights Used at Airport

Giant fluorescent floodlights which produce virtually glareless light now are being used at Logan International Airport, Boston, Mass., for the first time. The 8-foot tubular fluorescents recently were installed on the roof edge of the American Airlines loading section at the airport's terminal building. The installation is part of a joint experiment conducted by American Airlines and the General Electric Company to determine the practicability of fluorescent floodlighting for passenger loading ramps and maintenance areas.

A total of eight aluminum fixtures, bracketed to the hand rail of the observation deck 15 feet above the ground, comprise the installation. Each fixture contains two 8-foot long fluorescent lamps. A highly polished scientifically designed reflector directs light from the lamps through plastic windows to the loading areas.

Performance Calculations on Electric Couplings

P. H. TRICKEY
FELLOW AIEE

ELECTRIC INDUCTION COUPLINGS often are made with the field inside and the secondary outside exactly like an alternator. The field can be just as readily the outer member if desired. The secondary member often is made as a squirrel cage as in induction motors, and even more often is a simple ring of steel in which eddy currents are induced.

Although the coupling operates by inducing currents in the secondary and has a speed-torque curve somewhat like an induction motor, for any one condition of slip, it operates exactly like a short-circuited alternator and the same steady-state equations apply. The current is

$$I=\frac{e}{X_d}\,\frac{\sqrt{1+[(r_1/X_q)/s]^2}}{1+(X_q/X_d)[(r_1/X_q)/s]^2}$$

and the torque is $T=7.05/RPM_{\text{slip}}$ (I^2r_1Ph+Iron Loss+Friction + Windage) pound-feet. The resistances and reactances and their formulas are the same as for any synchronous machine. Table I shows a calculation sheet with an example on a small coupling. The sheet has been arranged for convenience of slide-rule operation. The formulas have been arranged around reactances calculated at an arbitrary slip and frequency (usually a slip giving a common frequency such as 60 cycles).

The maximum torque and slip at maximum torque are

$$T_{\max}=\frac{7.05}{\text{Syn}_f}\,\text{Ph}\frac{e^2}{X_d}0.5\,[A_m]$$

$$s_{\text{at max torque}}=\frac{r_1}{X_d}[C]$$

where A_m and C are found from Figure 1.

Table I. Calculation Sheet

1	Base freq. f (assumed)	60	6	X_d	87.0
2	Syn. speed at base freq., syn.$_f=\frac{120f}{P}$	3600	7	X_q	30.0
3	Friction and windage at syn.$_f$	17.5	8	X_q/X_d	0.345
4	Fe loss at base freq. and at volts	35.0	9	r_1/X_q	0.345
5	r_1 (hot)	10.34	10		

11	I_f field current	3.10		
12	E_{line} (from sat. curve at syn.$_f$)	217		
13	e = phase volts	125		
14	$im = e/X_d$ = (13)/(6)	1.44		
15	R.P.M.$_{\text{slip}}$	3600	900	112.5
16	s = slip = (15)/(2)	1.00	0.250	0.0312
17	(9)/(16) = $(r_1/X_q)/s$	0.345	1.38	11.04
18	$(17)^2=[(r_1/X_q)/s]^2$	0.126	1.90	122
19	$(18)(8)=[(r_1/X_q)/s]^2(X_q/X_d)$	0.0435	0.655	42.1
20	(19)+1.0	1.0435	1.655	43.1
21	$\sqrt{1+(17)^2}$	1.059	1.703	11.1
22	I=(14)(21)/(20)	1.46	1.482	0.371
23	$I^2R=(22)^2r_1ph$	66.0	68.3	4.26
24	Fe=(4)(16)² [(12)/ volts]²	35.0	2.2	
25	F+W=(3)(16)²	17.5	1.1	
26	Losses=(23)+(24)+(25)	118.5	71.6	4.26
27	Torque$=\frac{7.05}{(15)}(26)$ Lb ft	0.232	0.562	.266
28	R.P.M. input	3600	3600	3600
29	R.P.M. output	0	2700	3488
30	Watts input$=\frac{(27)(28)}{7.05}$	118.5	287	136
31	Watts output$=\frac{(27)(29)}{7.05}$	0	205	132
32	Eff.=(31)/(30)=(29)/(28)	0	0.75	0.9687
33	Hp input=(30)/746	0.159	0.387	0.182
34	Hp output=(31)/746	0	0.274	0.177
35	C (from Fig. 4)	1.17		
36	A_m (from Fig. 4)	1.26		
37	s_m=(35) (5)/(6)	0.139		
38	$T_m=\frac{7.05}{(2)}\left[\text{ph}\,.5\frac{(13)^2}{(6)}(36)\right]$* Lb ft	0.663		

* Neglecting Fe+F+W.

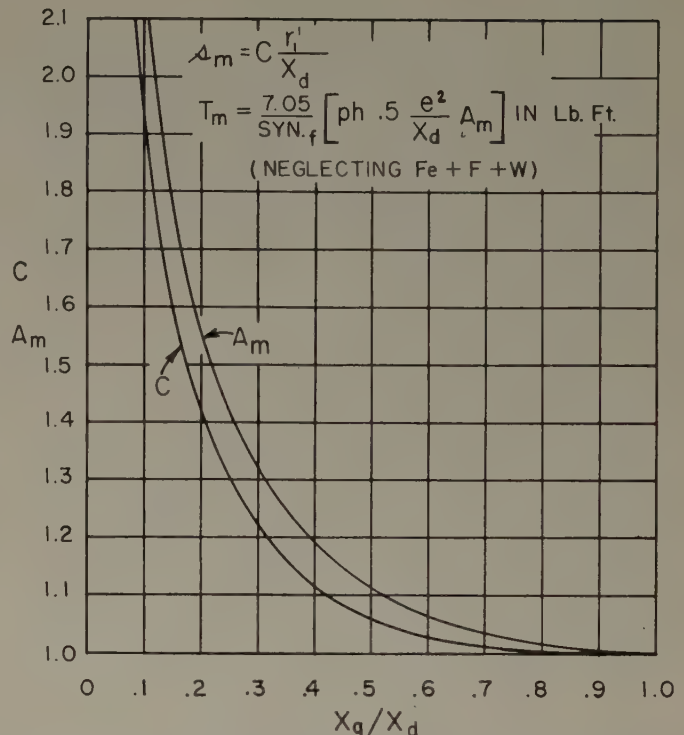

Figure 1. Maximum torque and slip at maximum torque of electric induction coupling

Digest of paper 52-65, "Performance Calculations on Electric Couplings," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The Magnetic Structure of Alnico 5

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In the investigation of Alnico 5, two problems arose. What is the mechanism which enables the alloy to respond to heat treatment in a magnetic field? What causes the alloy to have a high coercive force of 600 oersteds? The first problem has been solved and progress has been made toward solving the second.

ALNICO 5 IS the most important commercial permanent magnet alloy, and it is also one of the most interesting scientifically. It contains by weight 8 per cent aluminum, 14 per cent nickel, 24 per cent cobalt, 3 per cent copper, and 51 per cent iron, and it has the unique property that its figure of merit, $(BH)_{MAX}$, is increased threefold by heat treatment in a magnetic field. In investigating this alloy, we were concerned principally with two problems. First, what is the mechanism which enables the alloy to respond to heat treatment in a magnetic field? Second, what is the mechanism which causes the alloy to have a high coercive force of 600 oersteds? The investigation has been successful in solving the first problem and substantial progress has been made in solving the second.

The experimental work was guided by a current theory of Alnico 5 which satisfactorily accounts for most of the alloy's unique permanent magnet properties. This is the theory of Kittel, Nesbitt, and Shockley[1] which will now be briefly described. If we have a polycrystalline bar of Alnico 5 as shown in Figure 1 heat-treated in a field H_t in the direction indicated, the theory states that we will obtain plates of precipitate parallel to the field direction but not at right angles to it. The result will be that the bar will be divided up into plates of precipitate (dashed lines) and rods of matrix (area between dashed lines). The reason for this arrangement is that nuclei are formed parallel to the field, because in this direction they have a low demagnetizing factor while nuclei formed at right angles to the field have a high demagnetizing factor and are suppressed. The theory also states that the spacing between the plates of precipitate should be of the order of 1,000 angstroms or less. This is necessary in order that we may account for the coercive force on the basis of rotational changes in magnetization of single magnetic domains[2-4] rather than changes due to the movement of domain boundaries.

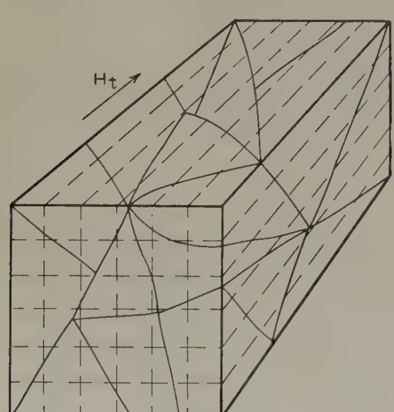

Figure 1. Polycrystalline bar of Alnico 5; heat-treated in field in direction indicated. Dashed lines show direction of precipitation according to theory

Revised text of conference paper recommended by the AIEE Magnetics Subcommittee of the AIEE Committee on Basic Structures and presented at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

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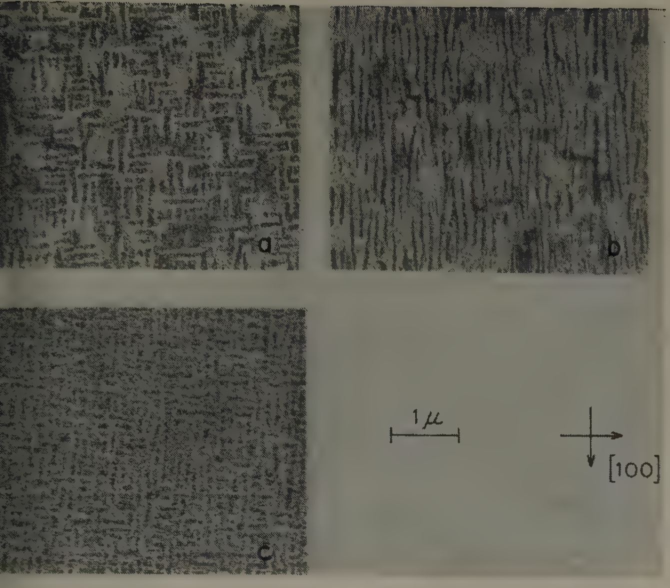
The authors are greatly indebted to R. M. Bozorth, W. Schockley, C. Kittel, J. H. Williams, and J. K. Galt for valuable discussions and suggestions during the work, and also to K. H. Storks for aid in interpreting the diffraction data and to F. G. Foster for optical examination of a large number of specimens. Mrs. M. H. Read and J. G. Walker assisted in the mechanical preparation and X-ray orientation of the specimens. The authors also wish to thank the *Journal of Applied Physics* for permission to publish the figures used in this article.

STRUCTURES DETERMINED BY ELECTRON METALLOGRAPHY

FIGURE 2 shows a remarkable experimental confirmation of the theory. These electron micrographs are thermal oxide replicas of single crystal[5] surfaces of Alnico 5 for the (100) plane. In Figure 2*b*, the crystal was heat-treated with the field (H) applied in the vertical direction as indicated, and the black precipitate is elongated in the field direction as predicted by the theory. In Figure 2*c* a cross section of the same crystal is shown. The plates of precipitate are now at right angles to each other but they are still parallel to the field direction, which is now normal to the surface. The experiment has added a refinement to the theory in that we now can see that the precipitate is in reality rods which form the general outline of plates. Figure 2*b* is a side view of the rods, and Figure 2*c* is an end view. Geisler[6] in his work on Alnico 5 has observed the general outline of plates.

The spacing between the rows of rods is approximately 200 angstroms, which is also within the limits predicted by the theory. The matrix has a body-centered cubic structure with a lattice constant approximately the size of iron (2.86 angstroms). The precipitate has a face-centered cubic structure with a lattice constant of 10.0 angstroms. The latter is new information not found by previous investigators and has been determined by electron diffraction. It is a transition structure, and in this respect it may be compared with martensite in the iron-carbon system. We do not know the chemical composition of this precipitate or its magnetic saturation. We do know that this structure is the agent responsible for the permanent magnet properties of the alloy. These properties occur when the precipitate is present and disappear when the precipitate is absent.



'igure 2. Electron micrographs illustrating effect of a magnetic ield, applied during the 2 degrees centigrade per second cool rom 1,300 degrees centigrade, on the permanent magnet pre- ipitate in Alnico 5. Single crystal, (100) face. Aged 2 hours at 800 degrees centigrade to grow the precipitate

a). Cooled 2 degrees centigrade per second from 1,300 degrees centigrade with no field

b). Cooled 2 degrees centigrade per second from 1,300 degrees centigrade with field along [100]

c). Section normal to applied field showing the ends of the rods of precipitate

Figure 2*a* gives us additional information about the pre- ipitate. This is the electron micrograph of the alloy vhen it is given the permanent magnet heat treatment 1,300 degrees centigrade cooled 2 degrees centigrade per econd in a magnetic field to 600 degrees centigrade, then ged at 600 degrees centigrade) except that the field is ot applied. In this state the precipitate grows in all hree <100> directions because of strong crystal forces. t appears from this micrograph that even though the lloy is not heat-treated in a field, fine particles of matrix nd precipitate exist, so that changes in magnetization ake place by a rotational process rather than by domain oundary movements. It also can be deduced from this nicrograph that the precipitate has a higher Curie point han the matrix because, if it did not, the matrix would ecome magnetic first on cooling, its spontaneous magne- ization would orient the precipitate in each domain just s the applied field does in the entire crystal, and the nicrograph would show regions similar to Figure 2*b*.

Unfortunately, even with the high magnification of the lectron microscope we cannot resolve the permanent nagnet structure when the alloy has been cooled so that t has optimum properties. The structures shown in 'igure 2 were for the alloy after it had been annealed at 00 degrees centigrade, and at this temperature the per- nanent magnet properties rapidly deteriorate. The pacing of the rows of precipitate rods for optimum per- nanent magnet conditions was obtained by measuring the pacing between rows when the crystal was heated at 800 legrees centigrade for various lengths of time and ex- rapolating to zero time. This curve is shown in Figure 3. The intercept for zero time at 800 degrees centigrade is 200 angstroms.

The curve also supplies experimental evidence that we have single magnetic domains in Alnico 5. When the rows of precipitate rods are 850 angstroms apart, the coercive force is only of the order of 20 oersteds. To obtain this low value of coercive force we must have domain boundaries. It seems unlikely that a mechanism which produces only 20 oersteds coercive force when the spacing is 850 angstroms could produce 600 oersteds coercive force when the spacing is 200 angstroms. An alternative solu- tion is that in the vicinity of 200 angstroms, the domain boundaries can no longer exist and the magnetization process has to take place by rotation. The latter mech- anism can account for the observed coercive force.

TORQUE MEASUREMENTS ON SINGLE CRYSTALS

MAGNETIC STUDIES constitute an important source of information for this alloy. In particular, the torsion[7] method of measuring the magnetic anisotropy was used. Briefly, it consists of rotating single crystal disk specimens (1/2 inch diameter, 1/16 inch thick) in a strong uniform magnetic field of 8,000 oersteds and measuring the torque necessary to turn the crystal away from a direction of easy magnetization. From these measure- ments, we find the easy direction of magnetization and the value of the crystal anisotropy constant, K, which measures the force necessary to rotate the magnetization out of the easy direction. Also, if the alloy consists of single mag- netic domains, we should be able to calculate the coercive force on the basis of this measured crystal anisotropy constant K, and compare this calculated value with the measured value obtained by the ballistic method.

Figure 4 shows the torque curves obtained on crystals cut in the (100) plane, which were quenched from 1,300 degrees centigrade and from 810 degrees centigrade. The 1,300 degrees centigrade temperature is the "solution" temperature for Alnico 5 and specimens quenched from this state consist mainly of a single body-centered cubic phase. If a specimen is cooled at an approximate rate of 2 degrees centigrade per second to 810 degrees centigrade and then quenched, it will also be mainly in the single- phase state. However, in the region of 810 degrees centigrade many nuclei are forming for the second phase precipitation but substantial precipitation of the second phase has not yet begun. For this reason the two torque

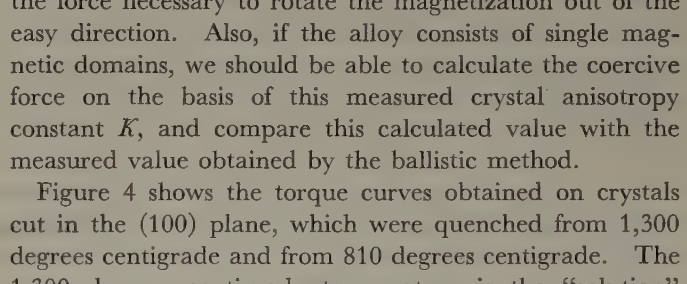
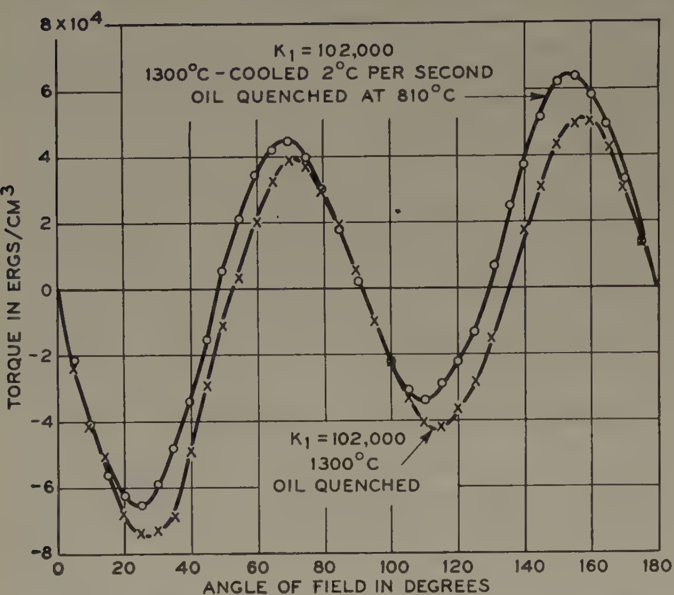


Figure 3. Plot of average distance between precipitate rows versus time at 800 degrees centigrade. The spacing in condition of maximum coercive force is obtained by extrapolating to zero time to yield a value of about 200 angstroms

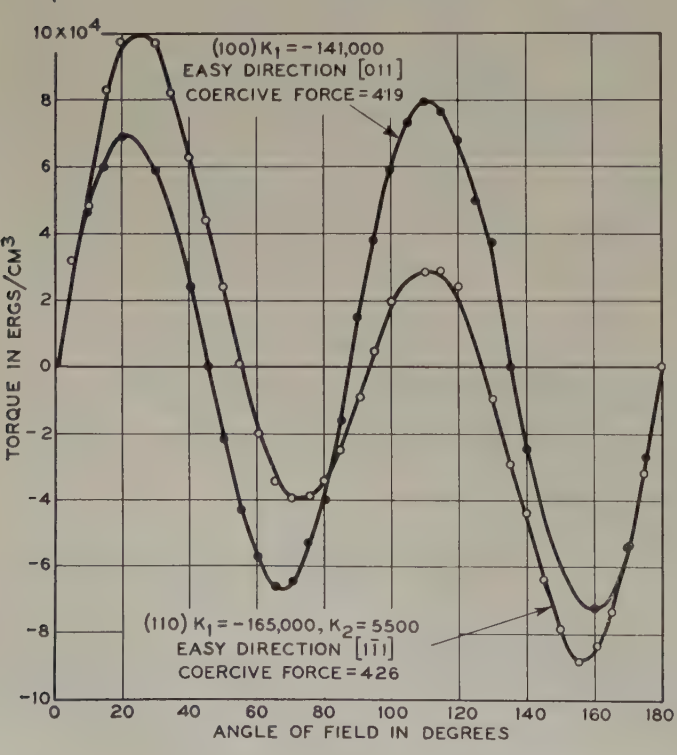
Figure 4. Magnetic anisotropy of quenched Alnico 5 single crystals, (100) plane



curves practically coincide. The curves show a simple fourfold symmetry (with some distortion) having an easy direction along the cube edges. The anisotropy constant K is low, being $+102{,}000$ or about one-fourth that of iron.

Figure 5 shows the torque curves obtained on crystals after the permanent magnet heat treatment but without the field applied during cooling. The latter was omitted so that the crystal anisotropy of the alloy could be measured to see if the coercive force of the alloy could be accounted for on this basis. The curve with the solid dots is for the crystal cut in the (100) plane and it exhibits fourfold symmetry which is characteristic of the cubic structure of the crystal in this plane. However, its easy direction has changed from the <001> to the <011>, and the anisotropy constant K has increased in absolute value and changed sign and is now $-141{,}000$.

Figure 5. Magnetic anisotropy of Alnico 5. Single crystals not heat-treated in a field, aged at 590 degrees centigrade



The curve with the open circle points is for the crystal cut in the (110) plane, and it exhibits twofold symmetry which is characteristic of the cubic structure in this plane. Its easy direction has changed from [001] to [1$\bar{1}$1] and its anisotropy constant K_1 is $-165{,}000$, which is in approximate agreement with the value obtained for the (100) plane. We may further check this value of anisotropy if we measure a (100) crystal which has been heat-treated in a field perpendicular to its face. The microstructure obtained

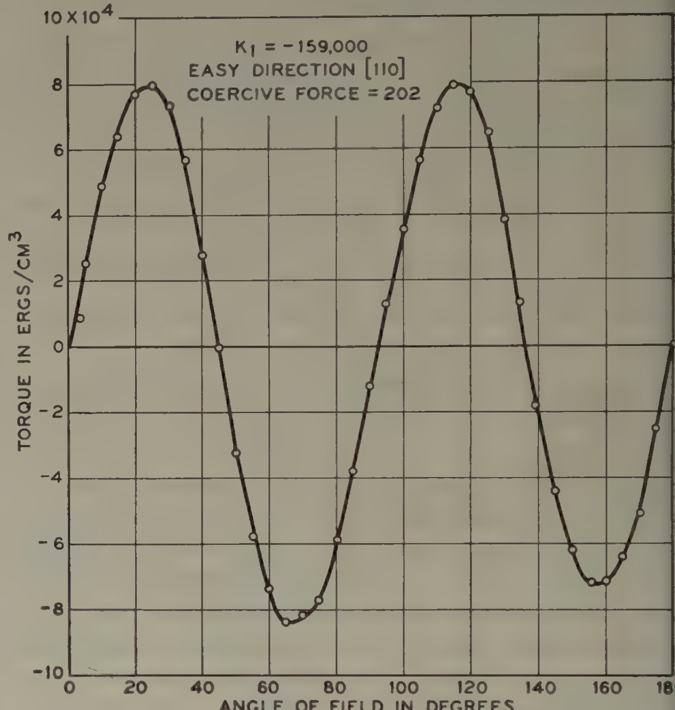


Figure 6. Magnetic anisotropy of Alnico 5. Single crystal (100) disk heat-treated in a field perpendicular to its face, aged at 590 degrees centigrade

by this heat treatment is more uniform than that obtained when no field is applied as shown in Figure 2a and c. We should find therefore that the torque curve is more uniform, and this is verified in Figure 6. The anisotropy constant K computed from this torque curve is $-159{,}000$ which again agrees with the two other values obtained.

According to the fine particle theory, the coercive force is $2K_1/I$ or $2 \times 159{,}000/1{,}100$ or 290 oersteds. Therefore, the coercive force due only to crystal anisotropy is about 300 oersteds and this value is too low to account fully for the coercive force (600 oersteds) of the alloy heat treated in a field. Evidently for the latter heat treatment an additional mechanism must be assumed besides crystal anisotropy to account for the final coercive force. The electron micrographs in Figure 2b indicate that the particles (both precipitate and matrix rods) have shape anisotropy

and this mechanism can easily account for the remaining 300 oersteds coercive force.

CRYSTALS HEAT-TREATED IN A FIELD

FIGURE 7 SHOWS torque curves for crystals heat-treated in a field in the various crystallographic directions and these curves also indicate strong shape anisotropy. They have a simple twofold symmetry which is not characteristic of the crystal symmetry and the anisotropy varies considerably depending upon the direction of the field during heat treatment. This is because there are strong crystal forces tending to make the precipitate lie in <100> directions. When the field and crystal forces are parallel we get the best alignment of precipitate and the highest anisotropy. For example, values of anisotropy constant of 960,000 and 910,000 were obtained for the (100) and

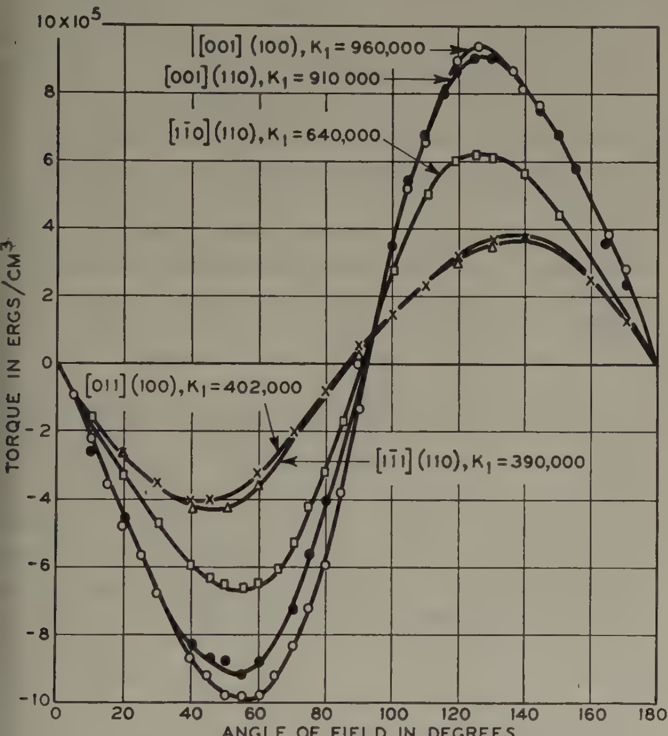
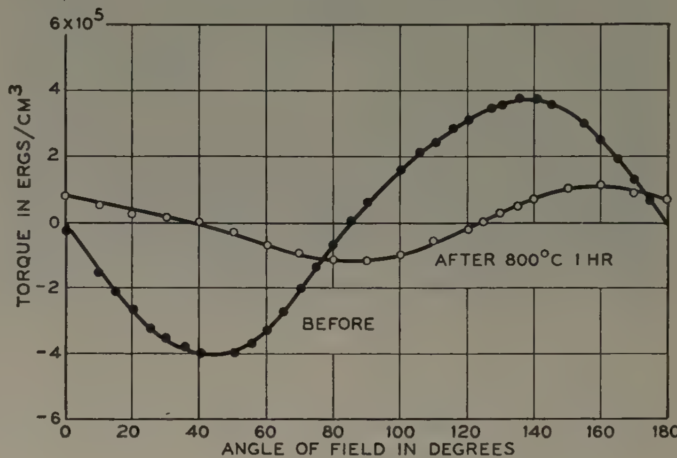


Figure 7. Magnetic anisotropy of Alnico 5. Single crystals heat-treated in a field in the direction and parallel to the plane indicated

(110) planes respectively when the field was applied in a [001] direction during heat treatment.

However, when the field is applied in a [1$\bar{1}$0] direction in the (110) plane then the field makes an angle of 45 degrees with two <100> directions and there is a conflict between the field and crystal forces. This results in a lower value of anisotropy (640,000) since some of the domains formed are not parallel to the plane of the disk under measurement, and therefore are in an unfavorable position to exert torque with the applied field. The most unfavorable case from this standpoint is when a crystal, cut in the (110) plane, is heat-treated in a field in a [1$\bar{1}$1] direction. Then the field does not favor any of the three <100> directions with the result that there is a considerable scatter of precipitate about the field vector. As a result

Figure 8. Magnetic anisotropy of Alnico 5. Crystal (110) plane before and after heat treatment at 800 degrees centigrade for 1 hour. Previously heat-treated with field in [1$\bar{1}$1] in plane of disk and aged at 590 degrees centigrade



the anisotropy constant is only 390,000, but this is more than twice the value of the crystal anisotropy and the curve still has the simple twofold symmetry which is characteristic of the magnetic field heat treatment.

EFFECT OF 800-DEGREE CENTIGRADE TREATMENT

IF AN Alnico 5 crystal is heated to 800 degrees centigrade after being treated to obtain permanent magnet properties, the precipitate will grow so that it can be studied by the electron microscope. Figure 8 shows torque curves taken before and after this 800 degrees centigrade treatment on a crystal cut in the (110) plane and heat-treated in a [1$\bar{1}$1] direction. After the permanent magnet heat treatment, the easy direction of magnetization is the field direction, [1$\bar{1}$1], but after the 800 degrees centigrade treatment it has shifted 40 degrees from the [1$\bar{1}$1] to within 15 degrees of the [001] direction.

The reason for this large shift in the direction of easy magnetization is clearly shown in the electron micrograph of Figure 9. Here we observe that the precipitate itself is

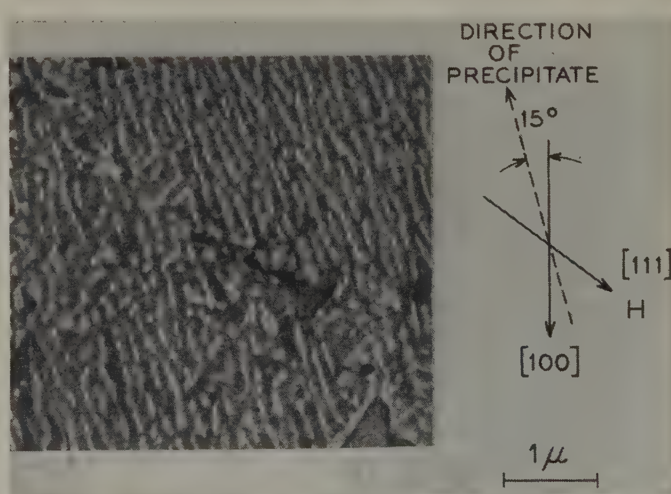


Figure 9. Electron micrograph of Alnico 5 crystal heat-treated in a magnetic field along a [1$\bar{1}$1] direction and aged at 800 degrees centigrade

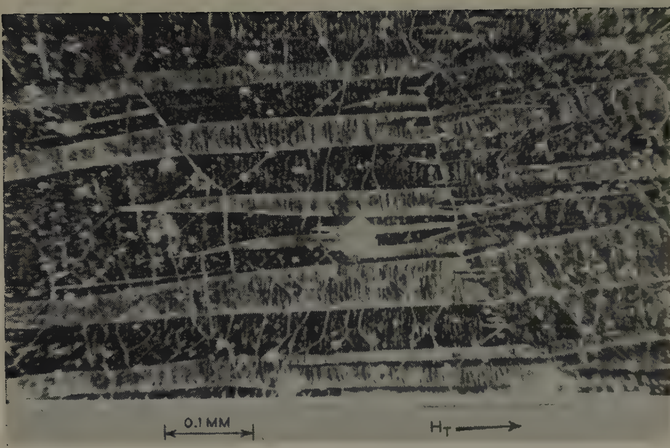


Figure 10. Magnetic powder pattern of Alnico 5 crystal

lying within 15 degrees of the [001] direction. Thus, the easy direction of the crystal has shifted 40 degrees upon heating to 800 degrees centigrade because the precipitate itself has shifted 40 degrees. It also appears that the stable position for the precipitate after an 800-degree centigrade heat treatment is the <100> directions.

DIRECTION OF DOMAIN MAGNETIZATION

THERE HAS been a considerable amount of discussion in the literature[8–10] as to whether the domain magnetization in Alnico 5 follows the field direction or the nearest <100> direction. H. J. Williams and the authors[11] attempted to settle this problem by taking a magnetic-powder pattern on a polycrystalline sample of Alnico 5 which was rapidly cooled in a magnetic field so that the domains would still be large enough to see. The result is shown in Figure 10, where we observe that the general effect is for the domain magnetization to follow the field direction. However, it can be observed from the illustration that sometimes the domains bend away from the field direction at the crystal boundaries by about 12 degrees. This deviation also has been found in torque measurements on single crystals. When the field was applied in the principal crystallographic directions, the domain magnetization

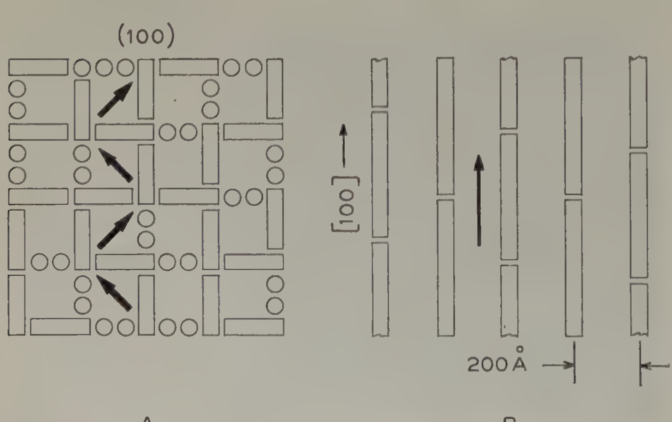


Figure 11. Simplified permanent magnet structure showing domain orientation

A. Without heat treatment in magnetic field
B. With heat treatment in magnetic field

followed the field but when the field was applied at an intermediate angle then the domain magnetization ben[t] toward the <100> direction of the order indicated i[n] Figure 10.

A SIMPLE PICTURE OF THE ALNICO 5 MECHANISM

FIGURE 11 SHOWS the simplified magnetic and physica[l] structure of Alnico 5 in the (100) plane deduced fro[m] the torque measurements on single crystals and the electro[n] micrographs of Figure 2. When the material is no[t] heat-treated in a field, we see that the precipitate rods gro[w] in the three <100> directions, the circles being the ro[d] ends. This results in the matrix being cube-shaped wit[h] its domain magnetization lying in a <011> direction i[n] the (100) plane.

From this type of domain arrangement we shoul[d] expect to obtain a residual induction of approximatel[y] 0.7 of saturation. This is confirmed experimentally sinc[e] we obtain approximately 9,000 gauss for residual inductio[n] and 13,000 gauss for saturation when the alloy is not heat[-]treated in a field. When the structure is heat-treated in [a] field in the [001], a single easy direction of magnetizatio[n] is established in the field direction and the transvers[e] precipitation is suppressed. This causes the large increas[e] in residual induction of the alloy, and from this domai[n] arrangement we should expect practically the value o[f] saturation for residual induction. This is borne ou[t] experimentally since we may obtain residual inductions o[f] approximately 13,000 gauss in Alnico 5 after heat treatmen[t] in a field.

Also, according to the theory of fine particles, if th[e] shape effect of the magnetic domains is increased by hea[t] treatment in a magnetic field as indicated in the electro[n] micrographs and torque measurements, the coerciv[e] force of the alloy should increase. This, too, is borne ou[t] experimentally since the coercive force of the single crystal was increased approximately 150 oersteds due to hea[t] treatment in a magnetic field.

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Temperature Differentials in Single-End Ventilated Integral-Horsepower Motors

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FELLOW AIEE

It has been found that glass-tube thermometers are seldom used for determining motor-winding temperatures and that thermocouples provide more accurate results and are more convenient to use. It is recommended that thermocouples be specified instead of thermometers using the present temperature limits now specified for the rise-by-resistance method.

IN SPECIFYING the full-load temperature rise of the windings of single-phase and polyphase integral-horsepower motors, National Electrical Manufacturers Association (NEMA) Publication Number *MG1-1949*[1] maintains a difference between temperature rise by resistance and temperature rise by thermometer of 10 degrees centigrade, except in the case of totally enclosed fan-cooled motors, where this difference is 5 degrees centigrade. For instance, the following values are specified for integral-horsepower single- and polyphase motors having Class A insulation:

	Temperature Rise, Degrees Centigrade By Thermometer	By Resistance
General-purpose motors	40	50
Totally enclosed motors	55	65
Totally enclosed fan-cooled motors	55	60
All others	50	60

A possible reason for the smaller differential between the temperature rise by resistance and the temperature rise by thermometer of totally enclosed fan-cooled motors might be the fact that these motors usually have single-end ventilation and the windings on the fan end are much cooler than on the other end. During the last 10 years several manufacturers have produced general-purpose open-type motors with single-end ventilation and the question arises as to whether there should be a 5-degree or 10-degree differential between the temperature rise by resistance and the temperature rise by thermometer on single-end ventilated open-type motors.

COMMERCIAL PRACTICES VERSUS STANDARDS

BEFORE PRESENTING the results of tests on single-end ventilated motors, it seems advisable to compare present commercial practices in the measurement of temperature rise with those in use when the AIEE Standards[2] were originally adopted. At that time most motor manufacturers still were using glass-tube thermometers for measuring the temperatures of motor windings, while today they are using surface thermocouples for the same purpose, principally because the latter are economical and convenient. Definition *2054* of the American Standards for Rotating Electric Machinery[3] defines the "Thermometer Method of Temperature Determination" as follows: "This method consists in the determination of the temperature by mercury or alcohol thermometers, by resistance thermometers, or by thermocouples, any of these instruments being applied to the hottest part of the machine accessible to mercury or alcohol thermometers." If this definition were followed to the letter, it should make no difference whether the temperatures are measured using glass-tube thermometers or thermocouples. In practice however, the definition is not followed and the thermocouples are placed on the hottest part of the machine accessible to thermocouples, thus obtaining much higher temperatures which are much nearer the actual temperature of the windings. For instance, E. R. Summers[4] in his paper, "Determination of Temperature Rise of Induction Motors," presented at the AIEE Winter Meeting, January 23–27, 1939, submitted the results of tests on 228 motors from 10 to 1,000 horsepower as follows:

Number of Tests Averaged	Mechanical Construction	Temperature Rise, Degrees Centigrade Hottest Surface	By Resistance
65	Fan-cooled	48	46.9
26	Totally enclosed	39.5	40.1
41	Splashproof	30.8	29
96	Open	29	26.9
228		35.9	34.6

These tests show that the temperature rise of integral-horsepower motors measured by surface thermocouple average as much or more than the rise by resistance.

At the AIEE Summer Meeting, June 24–28, 1940, C. G. Veinott[5] presented a paper, "Some Problems in the Standardization of Temperature Ratings of Fractional-Horsepower Motors," and submitted the results of 585 temperature tests taken on fractional-horsepower motors. These tests are not tabulated, but are plotted on curves, and from them Veinott reached the following conclusions:

"The important conclusions of this paper, all of which relate only to fractional-horsepower motors, are:

1. The temperature rise of single-phase induction motors measured by surface thermocouples average as much or more than the rise by resistance.

2. The surface thermocouple method of temperature

Full text of paper **52-144**, "Temperature Differentials in Single-End Ventilated Integral-Horsepower Motors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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measurement should be recognized as a distinct method instead of classifying it with the thermometer method as done in the present AIEE Standard Number 1. For purposes of rating, the limits assigned to this method may be the same as those assigned to rise by resistance.

3. If the method of determining the temperature rise of single-phase motors is to be changed, the present limit of 40 degrees centigrade by thermometer could be changed to 50 degrees centigrade by resistance or 50 degrees centigrade by surface thermocouple, without appreciably affecting actual temperature rises."

TESTS ON SINGLE-END VENTILATED MOTORS

THE RESULTS OF 92 commercial temperature tests made on 4-pole 60-cycle single-end ventilated open-type motors at the Wagner Electric Corporation are summarized as follows:

Frame Size	No. of Tests	Temperature Rise, Degrees Centigrade By Surface Thermocouple	By Resistance
224–5	14	28.1	27.3
254	15	34.7	36.9
284	22	36.1	36.9
324–6	31	42.6	39.2
364	10	40.3	42.5
224–364	92	36	36.4

In 46 tests or 50 per cent of the total, the difference between temperature rise by resistance and temperature rise by surface thermocouple was 2 degrees centigrade or less, and in 68 tests or 74 per cent of the total, this difference was 3 degrees centigrade or less. In other words, for all practical purposes the temperature rise by resistance is the same as the temperature rise by surface thermocouple on this type of motor.

In order to obtain information regarding the relation of hot-spot temperature in a single-end ventilated open-type motor to temperature rise by surface thermocouple and resistance, a 30-horsepower single-end ventilated 1,750-rpm motor was built in a 365 frame. The frame had no openings and a larger-than-rotor-diameter blower drew the air in one end-plate, forced it over the stator punchings and windings, and out the other end-plate. A large number of thermocouples were located throughout the winding, and surface thermocouples also were placed on the stator punchings and windings. At full load this motor had a 44.4 degrees centigrade temperature rise both by hottest surface thermocouple and resistance and a hot-spot temperature rise of 53.2 degrees centigrade. The latter was in the part of the windings nearest the upper part of the rotor and about halfway between the core iron and the tip of the coil. It will be seen that the temperature differentials in this motor were about the same as those previously reported in other types of open motors.

CONCLUSIONS

FROM THE DATA submitted, the conclusion is reached that the temperature differentials in single-end ventilated open-type motors are substantially the same as for double-end ventilated motors, and that no changes are desirable in the temperature standards on that account. It seems desirable, however, to revise these standards for other reasons. Ordinary glass-tube thermometers are very seldom used for measuring motor-winding temperatures, while thermocouples are commonly used for that purpose. The latter gives much more accurate results and are more convenient and dependable. Therefore, it is recommended that:

1. The "Thermometer Method of Temperature Determination" be abolished for rotating electric machinery.

2. The "Thermocouple Method of Temperature Determination" be defined and specified in its place using the present temperature limits now specified for the rise-by-resistance method.

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Military Wire Insulation Improved

A new aircraft wire developed to meet electronic wiring applications for military aircraft features a polyvinyl chloride plastic primary insulation and a nylon jacket extruded on the wire. A product of the Surprenant Manufacturing Company, Boston, Mass., the wire meets all requirements of military specifications. The polyvinyl chloride plastic primary covering, made from the B. F. Goodrich Company's Geon resin, helps to provide the wire with resistance to cold weather (−54 degrees centigrade plus or minus 1 degree without cracking), oil, grease, fungus, abrasion, and flame. Vinyl is self-extinguishing when the source of flame is removed. The nylon jacket provides additional protection against these hazards. The combination of a compound made from polyvinyl chloride and nylon meets all United States Air Force requirements for use in contact with Skydrol hydraulic fluid.

A New Electric Locomotive for the Pennsylvania Railroad

F. D. GOWANS B. A. WIDELL MEMBER AIEE ALFRED BREDENBERG MEMBER AIEE

Simplicity and reliability are the keynotes of the design of the new single-phase a-c electric locomotives for the Pennsylvania Railroad. Latest improvements in materials and manufacturing processes are fully utilized to create a motive power unit of high capacity.

RAPIDLY increasing use of diesel-electric locomotives has caused much speculation on the future of railroad electrification. Proponents of the diesel-electric point to its lower first cost, while the electric locomotive enthusiast claims lower maintenance and operating costs. The final answer will be an economic one, dependent upon such things as future electric power developments and new sources of fuel oil supplies.

The essential fact is that the railroads have accepted the electric drive as the best and most efficient means yet developed for propelling railroad vehicles. Of prime importance is the continued improvement of the components of this drive—whether for straight electric or diesel-electric locomotives—and the vehicle which it propels.

One important factor in the success of a locomotive is the type and arrangement of the mechanical parts. Past designs with many axles (some idle), complicated trucks, and crowded cabs resulted in high first cost, difficult manufacture, and expensive maintenance. When the General Electric Company was afforded the opportunity of designing a new freight locomotive for the Pennsylvania Railroad, serious consideration was given to all phases of this problem.

Freight traffic on the road's electrified lines was studied over a period of years to determine what size unit would give the best utilization. A 4-axle locomotive unit capable of operating in 1-, 2-, 3-, or 4-unit combinations was chosen. Experience showed that tonnage ratings should be based on average tractive effort over the ruling grades equal to 16-per-cent adhesion. At the 60,000-pound axle loading limit specified by the railroad, this amounted to a 1-hour tractive effort rating of 38,400 pounds per unit.

Table I shows how such units could handle the railroad's freight traffic through a typical industrial cycle.

SELECTION OF ELECTRIC EQUIPMENT

EQUALLY IMPORTANT is the type and arrangement of the electric equipment. The locomotive type largely will determine this. The railroad was willing to consider motive power of types other than its present straight a-c locomotive, if advantages were indicated.

The a-c commutator motor is inherently a high-horsepower machine. Its chief advantage lies in its ability to take 25-cycle power from the trolley without intermediate conversion equipment. For this reason locomotive ratings are based entirely on the traction motors. With overvoltage transformer taps, motors can be operated at extremely high short-time ratings for accelerating heavy trains and ascending grades. The relative simplicity of the equipment permits good arrangement, making ample space available for maintenance and inspection. The additional weight and cost of the a-c motor are offset by the conversion equipment necessary if d-c motors are used.

Advantages were decidedly in favor of continuing with the straight a-c type of locomotive. This has been the basic motive power on the Pennsylvania's electrified lines since 1931 and has given commendable service. Railroad schedules, operating practices, and shop facilities have been built up around it. Twenty years' experience with this

Table I. Traffic Handling Through Typical Industrial Cycle

Number of Units	Per Cent of Freight Traffic		
	Peak	Normal	Depression
1	13	34	64
2	60	63	36
3	22	3	0
4	5	0	0

Table II. Locomotive Unit Data

Classification	B-B-240/240-4GEA632-11,000 volts, 25 cycles a-c
Weight	
Total locomotive, fully loaded	240,000 pounds
Per driving axle, fully loaded	60,000 pounds
Dimensions (Approximate)	
Track gauge	56 1/2 inches
Length inside knuckles	54 feet 3 inches
Height over cab roof	14 feet 0 inches
Height, trolley locked down	15 feet 0 inches
Width over cab sheets	10 feet 0 1/8 inches
Width over-all	10 feet 7 inches
Total wheel base	39 feet 10 inches
Rigid wheel base	11 feet 0 inches
Length between centerplates	28 feet 10 inches
Wheel diameter	48 inches
Coupler height	34 inches
Clearance, motor gear case to rail	4 5/8 inches
Minimum curve	275-foot radius, 21 degrees
Ratings	
Tractive effort at 25-per-cent adhesion	60,000 pounds
Tractive effort, continuous rating	35,400 pounds
Tractive effort, 1-hour rating	38,400 pounds
Speed, 1-hour rating	25.5 miles per hour
Maximum speed	65 miles per hour

Essential text of paper 52-23, "A New Electric Locomotive for the Pennsylvania Railroad," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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plant has demonstrated that simplicity of mechanical construction and of electric circuits is the key to low maintenance and reliable operation.

Table II gives weights, dimensions, and ratings of a single unit. Units may be coupled (Figure 1) for multiple operation from either end, with as many as four units operating together.

Characteristic speed-tractive effort curves for motoring are shown in Figure 2. These are for a 2-unit 5,000-horsepower locomotive.

Figure 1 (above). Two units operating in multiple as a 5,000-horsepower locomotive

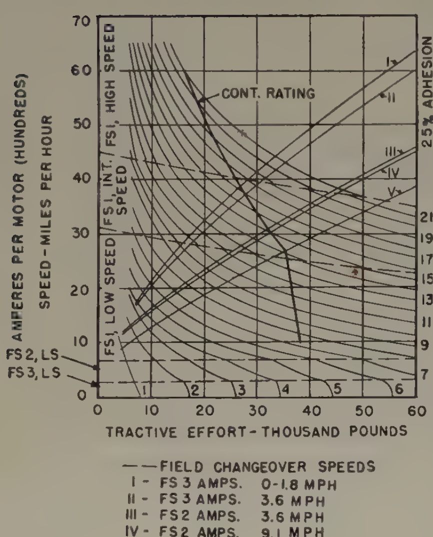

Figure 2. Speed-tractive effort curves for one 4-motor locomotive unit with 83:21 gearing and 48-inch wheels

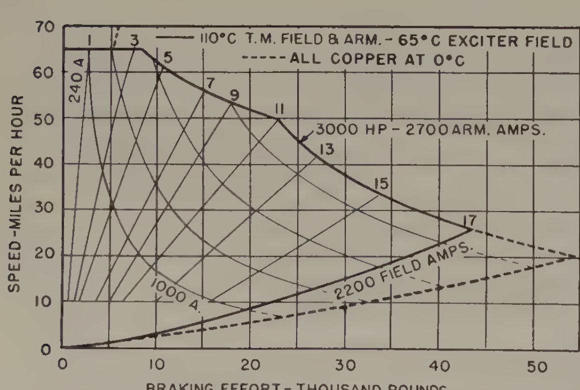

Figure 3. Speed-braking effort curves for one 4-motor locomotive unit with 83:21 gearing and 48-inch wheels

In recent years rheostatic braking, now commonly used on diesel-electric locomotives, has established its worth in dollars and cents. This usefulness, especially in freight service, has now resulted in its application on a straight a-c locomotive for the first time in the United States. Braking characteristic curves for the 2-unit locomotive are shown in Figure 3. The a-c commutator motors are well adapted for this use, rating 750 horsepower each during braking within the limits of maximum excitation and commutation.

MECHANICAL DESIGN

The mechanical design, with a streamlined single-end cab carried on two 2-axle swing-bolster trucks, is quite different from earlier a-c freight locomotives.

Locomotive platforms were formerly designed to carry the entire equipment load and withstand the buff without undue deflection. The cab side sheets and roof were part of the platform load. By designing the side sheets to prevent buckling, they can be used as side trusses to carry the entire load. The consequent reduction of material in the platform amounts to approximately 40 per cent, as compared with a 5-per-cent increase in the amount of side sheet material.

Conventional 2-axle swing-bolster trucks (Figure 4), generally similar to those on Pennsylvania Railroad passenger cars, are used.

LOCATION OF APPARATUS

Two factors largely determine locomotive inspection and maintenance costs: reliability of the equipment and its accessibility in the locomotive. In designing these units, prime consideration was given to the location of apparatus.

Figure 5 shows that the traction-motor control groups and blowers are located directly over the trucks. Bus-bar and cable runs are thereby kept to a minimum, and blowers discharge directly downward into the motors. Conditions at the rear end are ideal, but at the front end the control group and one blower had to be offset to accommodate the operating compartment. Both motor control groups receive power from the transformer and its control group which, together with the auxiliary equipment, is located centrally. Motor controls are accessible through doors along each side aisle. A crosswise main-

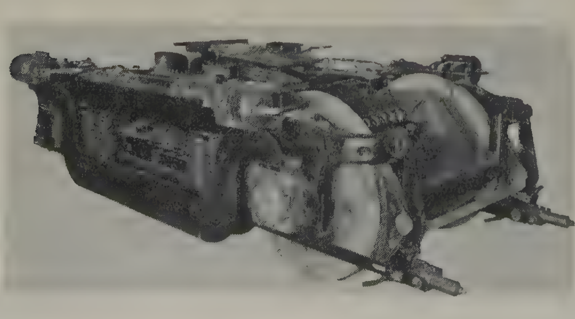

Figure 4. Two-axle swivel truck of conventional design used on this locomotive

tenance aisle for the transformer group extends from one side aisle to the other.

The location of the transformer high-voltage bushing and Thyrite* resistance lightning arrester on the roof is unusual. The transformer tank is the full height of the apparatus cab, allowing the bushing to protrude through a cutout in the hatch cover directly under the front pantograph. An insulated bus on the roof connects both pantographs, the lightning arrester, and the transformer. It also serves as the terminal for the ground-switch. This arrangement eliminates all 11,000-volt cable, cable preparation, and conduit, together with the shields and barriers necessary for the protection of workmen inside the apparatus cab from contact with the voltage.

The two pantographs on the roof of each unit are accessible from inside the cab by means of a ladder and hinged door in the hatch cover. This door is mechanically interlocked with the pantograph grounding switches to prevent access to the roof when the pantographs are ungrounded.

Considerable improvement has been made in auxiliary equipment. Axial-flow blowers contribute to better arrangement and accessibility because they occupy about half the space of comparable centrifugal blowers. The blowers incorporate an air-cleaning feature which removes about 60 per cent of the dirt, water, and snow from the air furnished to the electric equipment. The 3-phase induction motor drive eliminates the expense of brushes, commutator maintenance, and frequent inspection. Because of their good characteristics, these blowers have been used throughout.

An auxiliary motor-generator set provides 3-phase power for the blowers and d-c power for control and battery charging. Air-brake equipment is *8EL*, modified to permit application of speed control at a later date.

A new feature is the use of the diesel-electric-locomotive-type air compressor. It is coupled to a 25-cycle single-phase induction motor and arranged for unloaded starting. It has a capacity of 220 cubic feet per minute at 725 rpm.

TRACTION MOTORS

THE *GEA 632* MOTOR (Figure 6) is a 16-pole 25-cycle single-phase commutator-type a-c motor with commutat-

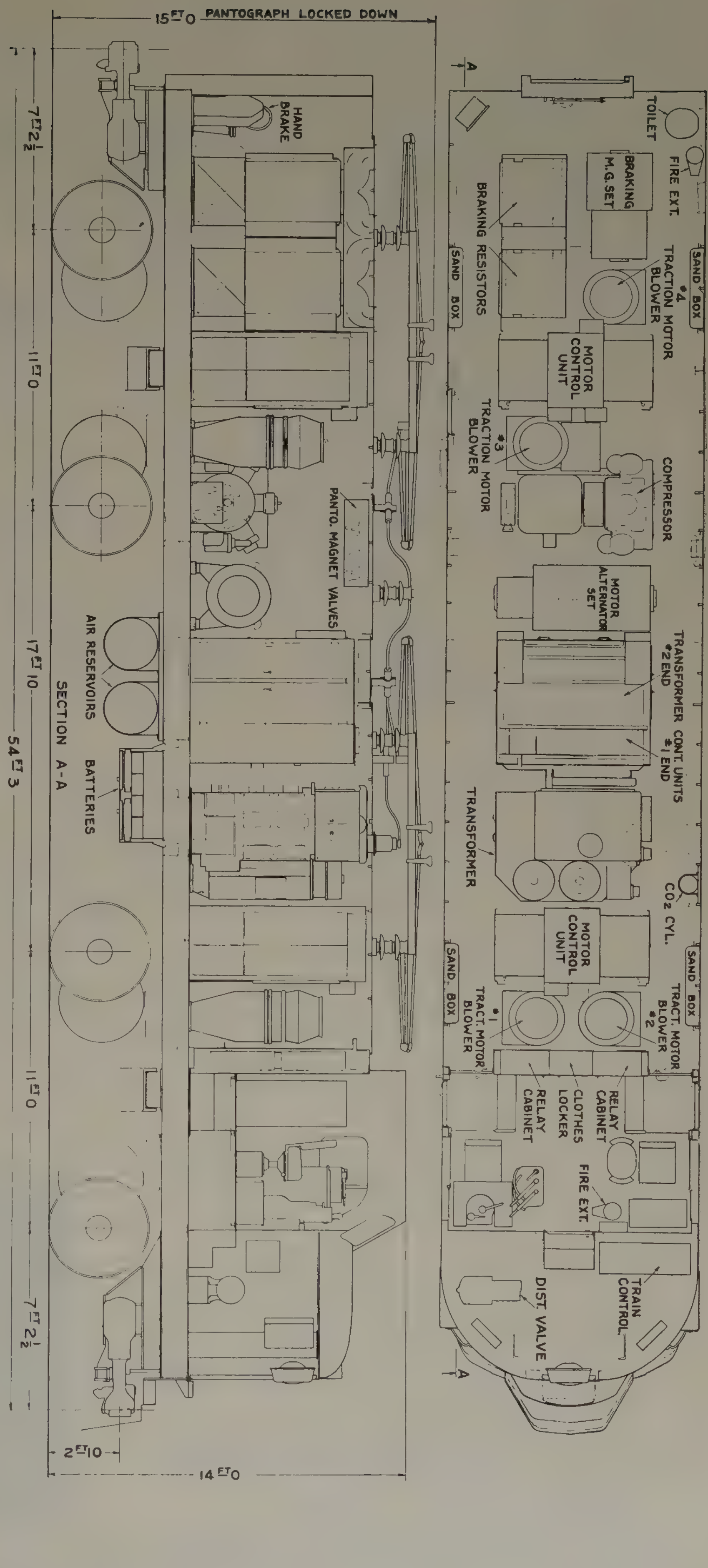

Figure 5. Location of principal pieces of apparatus in the locomotive cab

* Registered trade-mark of the General Electric Company.

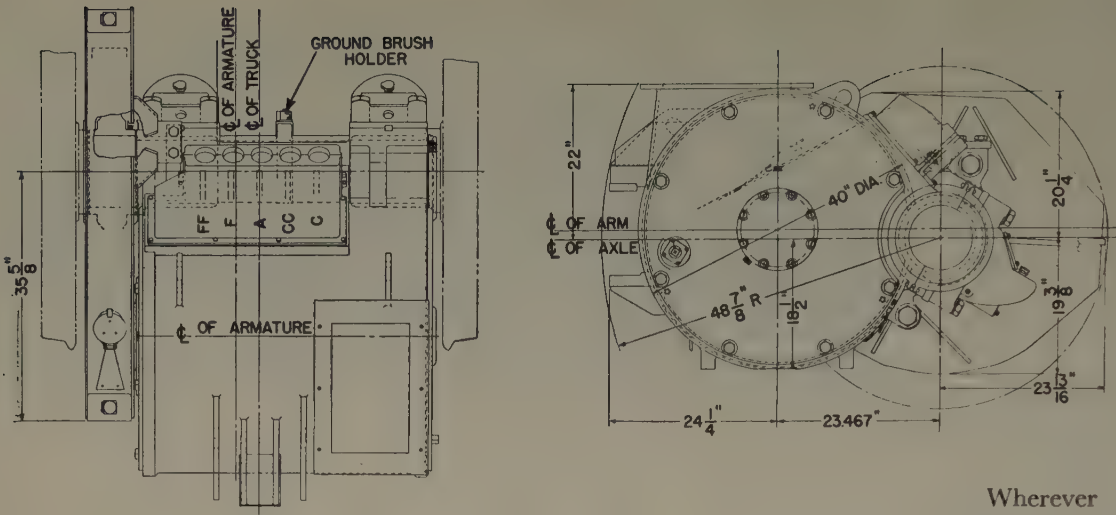

Figure 6. Outline of traction motor with principal dimensions

Table III. Motor Connections

Connection Number	Main Field Connection	Interpole Field Connection	Approximate Speed Range, Miles Per Hour	Contactors Closed*
1	Weak Field (FS3)	Low Speed (LS)	0 to 3	F12, F13, F14R, F24R
2	Intermediate Field (FS2)	Low Speed (LS)	3 to 7	F11, F12, F14R, F24R
3	Full Field (FS1)	Low Speed (LS)	7 to 26	F11, F14R, F24R
4	Full Field (FS1)	Intermediate Speed (IS)	26 to 40	F11, F14R, F24R, F15X, F25X
5	Full Field (FS1)	High Speed (HS)	Above 40	F11, F14X, F24X, F15X, F25X

* Contactors for number 1 and number 2 motors only are listed.

ing poles and pole-face windings. It is rated 625 horsepower continuously at 230 volts. The maximum operating speed is 1,800 rpm, corresponding to a speed of 65 miles per hour on these particular locomotives. The motor is mounted on the axle and a nose support on the truck transom. A cushion gear, pressed on the axle, is driven by the motor pinion.

It has long been recognized that better performance can be obtained from a straight-electric locomotive traction motor than from a diesel-electric or motor-generator locomotive motor. On a-c locomotives this extra performance is obtained by providing overvoltage taps on the transformer. The multipole low-flux-per-pole type of single-phase a-c motor is ideally suited to transmit this additional power. The first motors of this general type were placed in service on the Pennsylvania Railroad in 1931, and a very complete analysis of their design has been published.[1]

ELECTRIC AND MECHANICAL DEVICES

Electrical design points differing from former motors of similar type are

1. A slightly smaller exciting-pole air gap, and a larger commutating-pole air gap.

2. Armature slots that are open instead of partially closed, to permit using preinsulated coils with their inherent advantages.

3. Solid armature bar in place of the folded bar.

4. More armature slots per pole and shallower slots, to offset partially the additional losses in the solid armature bars at high speeds.

Wherever possible, mechanical details conform to the improvements made in d-c motor construction during the last few years. (See Figure 7.)

Brush holders are of the 1-piece type, light and simple in design. Ample clearances around the brush prevent its binding in the holder as a result of accumulations of dust.

Armature coils are of semi-one-piece split-throw design with flattened leads for connecting to the commutator risers. Less than half as many back-end brazes are required as formerly. The bars have a straight portion at the back-end connections of the winding to give additional surface for binding purposes.

A revolving brush-holder yoke permits inspection and replacement of brushes. This is located to line up the brush holders in correct relation to the main poles by a key set accurately with fixtures at the factory.

The cushion gear is similar to those used in the past, with the exception that tube-form synthetic rubber joints replace the flat or spiral steel springs formerly used to damp the 50-cycle torque impulses.

The continuous rating of the motor is given on the

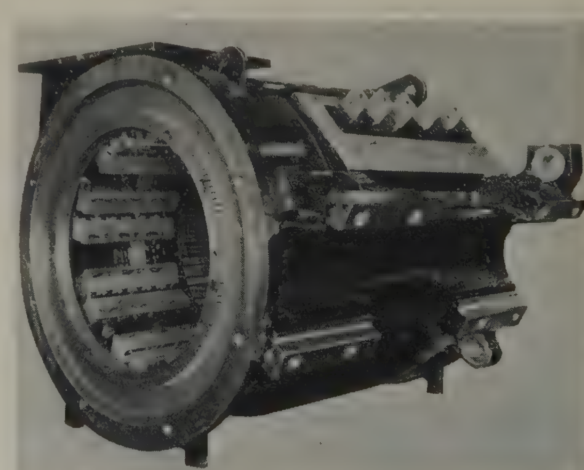

Figure 7. Traction motor stator with frame head removed to show brush holders and revolving yoke

AIEE basis for Class *B* insulation. Each motor is blown with 4,200 cubic feet of air per minute.

FLUX CONTROL

To limit the circulating current in the armature turns to a tolerable value at standstill and during very low-speed operation, the main field flux must be limited in amplitude. This is accomplished by a combination of autotransformer and induction shunt which weakens the field to 40 per cent of full strength (FS3, Table III). As the locomotive speed increases, the circulating currents decrease to the extent that, at 3 miles per hour, the autotransformer may be cut out. This gives 67 per cent main field strength (FS2, Table III). As a result, for a given motor torque (locomotive tractive effort) the motor line current is significantly reduced. At 7 miles per hour, main field shunting is completely removed. Operation then continues in full field (FS1, Table III) at higher speeds.

Three settings of commutating pole shunting are required to cover the locomotive speed range. The low-speed shunt, a resistive impedance, is connected across the commutating poles from standstill to 26 miles per hour. Above 26 miles per hour commutation again becomes unacceptable with this shunt. Supplementary resistive-reactor impedances are connected over the intermediate speed range from 26 to 40 miles per hour (connection number 4, Table III). Additional impedance is connected in the high-speed range above 40 miles per hour (connection number 5, Table III).

This new motor has been designed for a low best speed of commutation of 21 miles per hour, as compared to 25.5 miles per hour for older locomotives of similar capacity. Good performance is thus assured at relatively low speeds over long heavy grades as well as in high-speed service.

GENERATOR OPERATION

When the motors are operated as separately excited d-c generators and loaded on resistors for rheostatic braking, 39 per cent of the line current must be shunted out of the interpole field for best commutation. To prevent changes in interpole winding temperatures from causing appreciable changes in the amount of shunted current, a portion of the permanent low-temperature-coefficient resistance used across the interpole field in a-c operation is connected in series with the interpole field. The remainder is used to shunt the required amount of current out of the interpole and resistor leg.

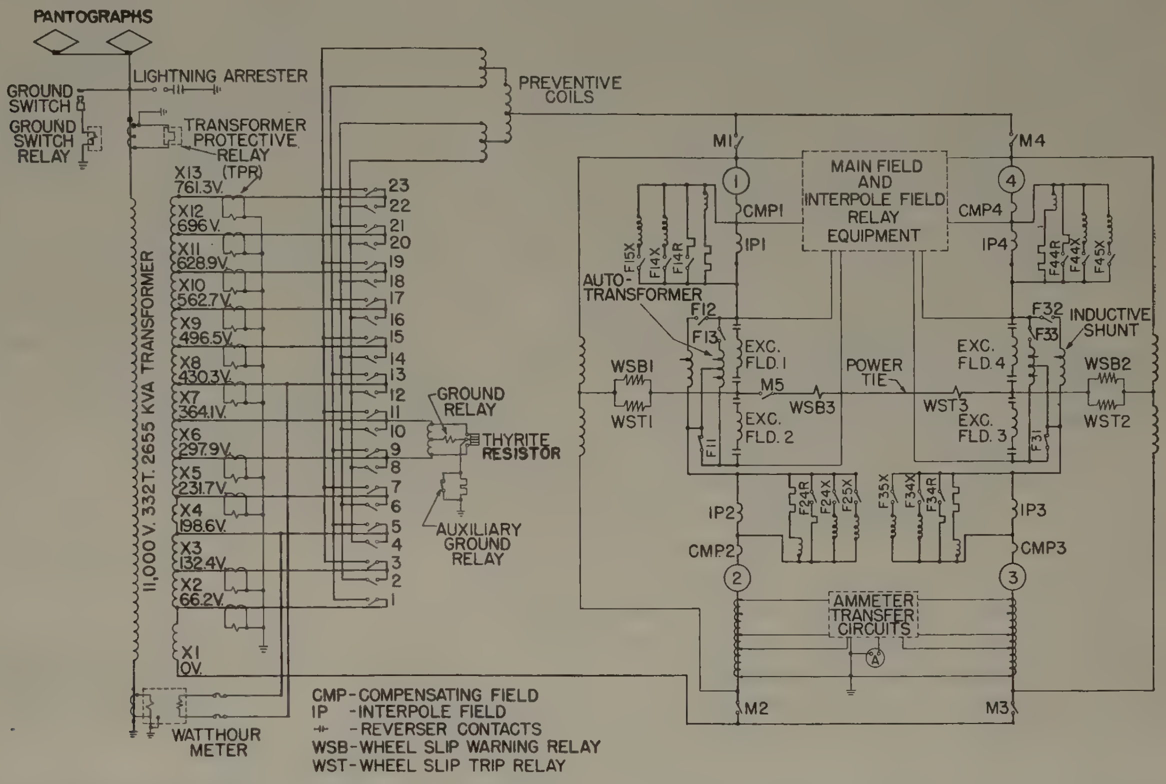

Figure 8. Schematic diagram of traction motor circuits for motoring operation

CONTROL EQUIPMENT

Multiple-unit single-end control of the electropneumatic type is used. The main transformer, rated at 2,655 kva, 11,000/762 volts, 25 cycles, single phase, is Pyranol* filled and forced ventilated.

The traction motors are connected in two parallel groups, each with two motors in series (Figure 8). Varying voltage steps are provided by the well-known 3-preventive coil system of notching on the taps of the transformer secondary. A total of 21 control steps gives acceptable tractive effort increments.

The main and interpole field connections are under the control of a 5-position motor-operated controller governed by the following relays in the traction-motor circuit:

1. Main field relay, of the phase-angle motor type, connected so that the rotor takes a position corresponding to the phase angle between the main transformer and

* Registered trade-mark of the General Electric Company.

traction motor field voltages. Thus the relay is responsive to locomotive speed and can be used to control the traction-motor field connections FS3, FS2, and FS1.

2. Two interpole field relays, identical except for speed setting. Each has an operating coil with one winding responsive to traction-motor armature voltage and the other (a differential winding) responsive to main field voltage.

For braking, the traction-motor armatures are connected in two groups (Figure 9) and operate as d-c generators across a constant-value braking resistor. All four motor fields are connected in series across a low-voltage d-c exciter. Control of braking effort and speed is obtained by varying the exciter shunt field. This is done manually through the braking handle on the master controller, which gives 17 braking steps. Each braking resistor is of the strip-ribbon type, cooled by a d-c motor-blower set connected across it.

OPERATION OF AUXILIARIES

Auxiliaries are driven by single-phase 25-cycle induction motors connected to taps on the main transformer secondary (Figure 10).

The motor-alternator set is manually controlled by the selector handle on the master controller. The blowers are started automatically by the closing of the alternator field contactor when the set comes up to speed.

Split-phase resistance starting is used on the motors of the auxiliary sets. A balanced-beam-type relay, connected to compensate for line voltage changes, allows starting over a wide range of applied voltage.

The master controller has a main handle to control acceleration, a reverse handle, a braking handle to control rheostatic braking, and a selector handle to control the motor-alternator set. Suitable mechanical interlocking prevents improper operation of these handles.

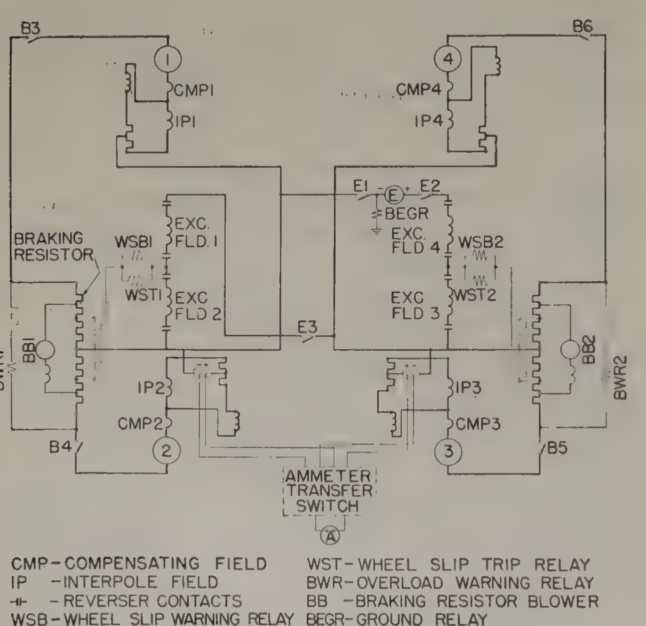

Figure 9. Schematic diagram of traction motor circuits, rheostatic braking connections

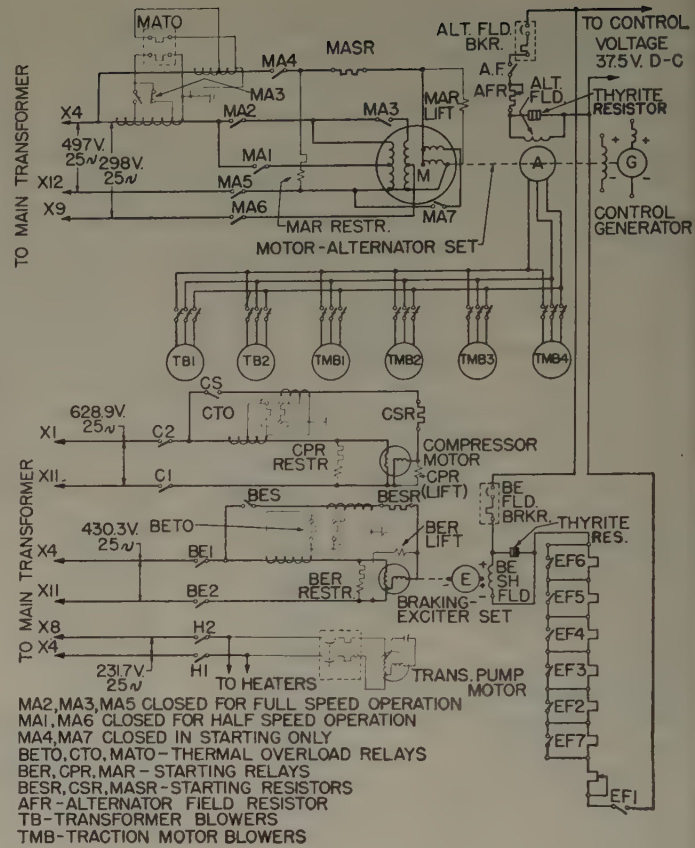

Figure 10. Schematic diagram of auxiliary circuits

Control of the transformer tap contactors for acceleration is obtained through intermediary sequence relays, one for each contactor. This simplifies the interlocking, and also precludes overvoltage on the preventive coils in case a contactor sticks closed.

Circuit and apparatus protection for these locomotives centers in a transformer protective relay for the main transformer and a ground relay for the traction-motor and auxiliary circuits. These are supplemented by wheel-slip relays for the traction motors and thermal overload devices for the auxiliaries.

In case of a ground on a traction motor or 25-cycle auxiliary, the ground relay makes a partial operation and opens the traction-motor line contactors and auxiliary contactors. After a faulty circuit has been isolated, operation (possibly at reduced locomotive capacity) may be continued.

Should the ground be on the transformer side of the line contactors, the ground relay makes a complete operation, automatically inserting resistance in series with its operating element. This permits emergency operation of the locomotive.

The transformer protective relay contains a thermal element to protect the primary winding, and magnetic trip coils to provide tap-to-tap protection for the secondary. Relay operation closes a pantograph grounding switch. After the trolley circuit breaker opens, the pantograph is lowered automatically.

There are two systems of wheel-slip protection for the traction motors. One system consists of two current-element relays (one to warn and one to trip) located in a power

tie connecting the mid-voltage points of both 2-motor series circuits, which are shown in Figure 8. Under heavy accelerating conditions there will be an appreciable weight transfer from the leading axle to the trailing axle in each truck. Hence, the leading axle will tend to slip first. In this case, the power tie causes one of the more heavily loaded axles to receive a current build-up and the more lightly loaded axle to get a reduction, thus minimizing the effect of a slip and maintaining tractive effort at a high value.

The other system comprises two a-c–d-c voltage relays in each 2-motor circuit. These operate on a difference in potential between the two motors in each group. They are particularly useful in rheostatic braking, or when one pair of motors is cut out as, in either case, the power tie is open.

Overcurrent protection in rheostatic braking is obtained by a voltage relay, connected across each braking resistor, which operates a warning light and buzzer at the operator's position.

Ground protection during rheostatic braking is furnished by a ground relay (BEGR) which operates warning lights in the operating cab and opens the braking power and exciter field circuits.

SUMMARY

These locomotives have been designed to meet certain basic requirements:

1. A unit size to give the most efficient use over a wide range of traffic conditions.
2. A well-proved type of electric equipment.
3. High horsepower. While the locomotives rates 625 horsepower per axle continuously at 26.5 miles per hour, it will accelerate trains up to 33 miles per hour at 25-per-cent adhesion (1,300 horsepower per axle) and haul tonnage trains over ruling grades at 41.5 miles per hour at 16-per-cent adhesion (1,060 horsepower per axle).
4. Ready access to equipment for inspection and maintenance.
5. Higher availability and lower operating expense.
6. Lower first cost.

Evidence from operation to date indicates that these objectives have been attained.

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Fault Characteristics of Aircraft Electric Systems

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MEMBER AIEE

Aircraft destruction can result from electric installations following the same principles successfully used in a normal industrial installation. Suggestions are made to clear faults of this type.

The protection of electric systems has been applied mainly to the prevention of damage to electric equipment caused by overheating or overstressing the components. Normal industrial installations result in systems which, while protecting the specific equipment for which they were designed, also give adequate protection to the surrounding equipment. Unfortunately, it has been assumed without serious reservation, that similar protective systems for aircraft equipment could perform the same function. In reality, however, the environmental conditions in aircraft operation are so much more severe, as the structure of the aircraft is much more vulnerable to arc damage, that they will require more extensive and efficient protection in the future. It would be rather pointless to install a system that assured the operation of specific equipment if, at the same time, it allowed the structure of the aircraft to be destroyed. Such a contingency can occur under the present philosophy of protection of aircraft electric systems.

Under the severe environmental conditions imposed by aircraft operation, two types of electrical faults are found: welded or solid faults, and arcing faults. Welded faults, which are characterized by high sustained values of current, limited mainly by the circuit resistance, cause extensive damage to the electric system with minor damage to the surrounding installations. Arcing faults, on the other hand, are characterized by the intermittent flow of current with magnitude limited by the arc and circuit resistance and the transient characteristics of the power source;

Full text of paper 52-138, "Characteristics of Faults on Aircraft Electrical Systems," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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these faults may cause severe structural damage with little effect on the electric system.

FAULTS

The philosophy that faults are self-clearing long since has been discarded. With high-capacity generating systems, various types of protection have been used. With overvoltage protection, differential protection, reversed polarity protection, automatic equalizer disconnects, and other types, the electric system is well attended. These types of equipment normally will remove a faulted section without serious damage to the electric equipment. Since these methods of protection have been well described in the literature, and are applicable to welded faults, no further mention will be made of welded faults.

Insufficient attention has been given to faults giving rise to a continuous or intermittent arcing. Laboratory tests indicate average current levels of a few amperes on circuits ranging from Army-Navy (AN) size 18 to 1/0 cable. Obviously, the problem of detecting such small average current differentials on circuits capable of carrying several hundred amperes will be exceedingly difficult. To obtain data that would yield useful information on the characteris-

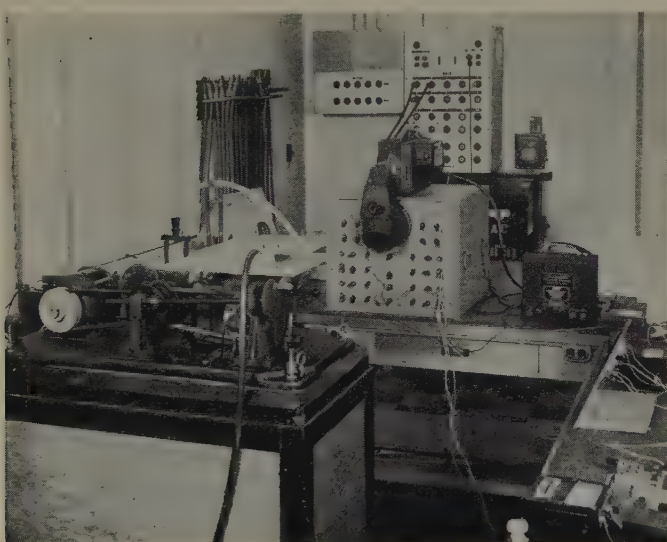

Figure 1. Laboratory installation for the study of arcing faults showing the method of mounting the aluminum ground plane and the cable used to establish the fault

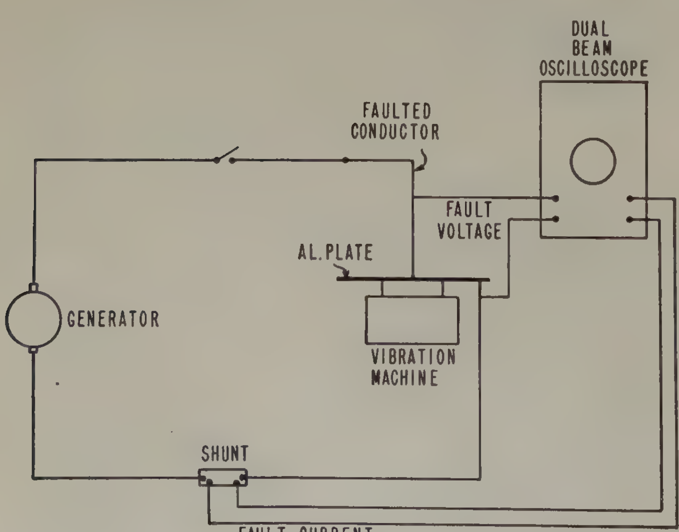

Figure 2. Schematic diagram of the circuit used in the study of arcing faults

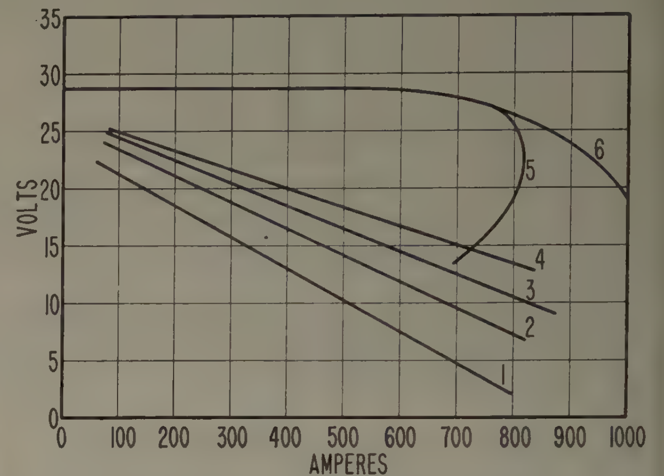

Figure 3. Steady-state and transient characteristics of a 30-volt 400-ampere aircraft generator

Transient characteristics:

1. *One generator, no load*
2. *One generator, 200 amperes load*
3. *One generator and battery, no load*
4. *One generator and battery, 200 amperes load*

Steady-state characteristics:

5. *One generator*
6. *One generator and battery*

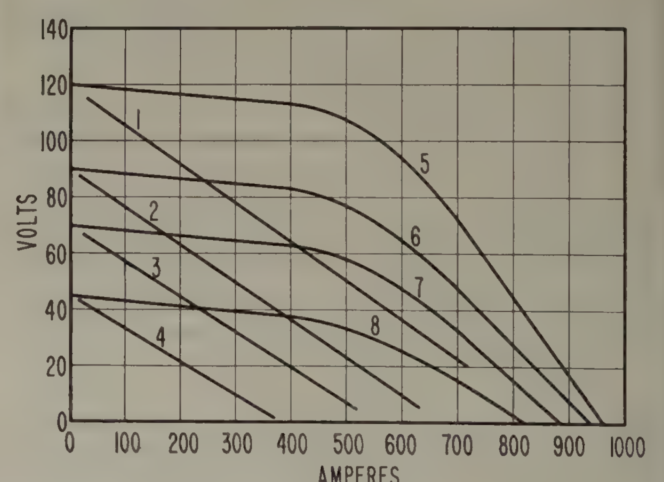

Figure 4. Steady-state and transient characteristics of variable-voltage-source 200-ampere 12- to 120-volt d-c generator

Transient characteristics:

1. *120 volts, no load*
2. *90 volts, no load*
3. *70 volts, no load*
4. *45 volts, no load*

Steady-state characteristics:

5. *120 volts*
6. *90 volts*
7. *70 volts*
8. *45 volts*

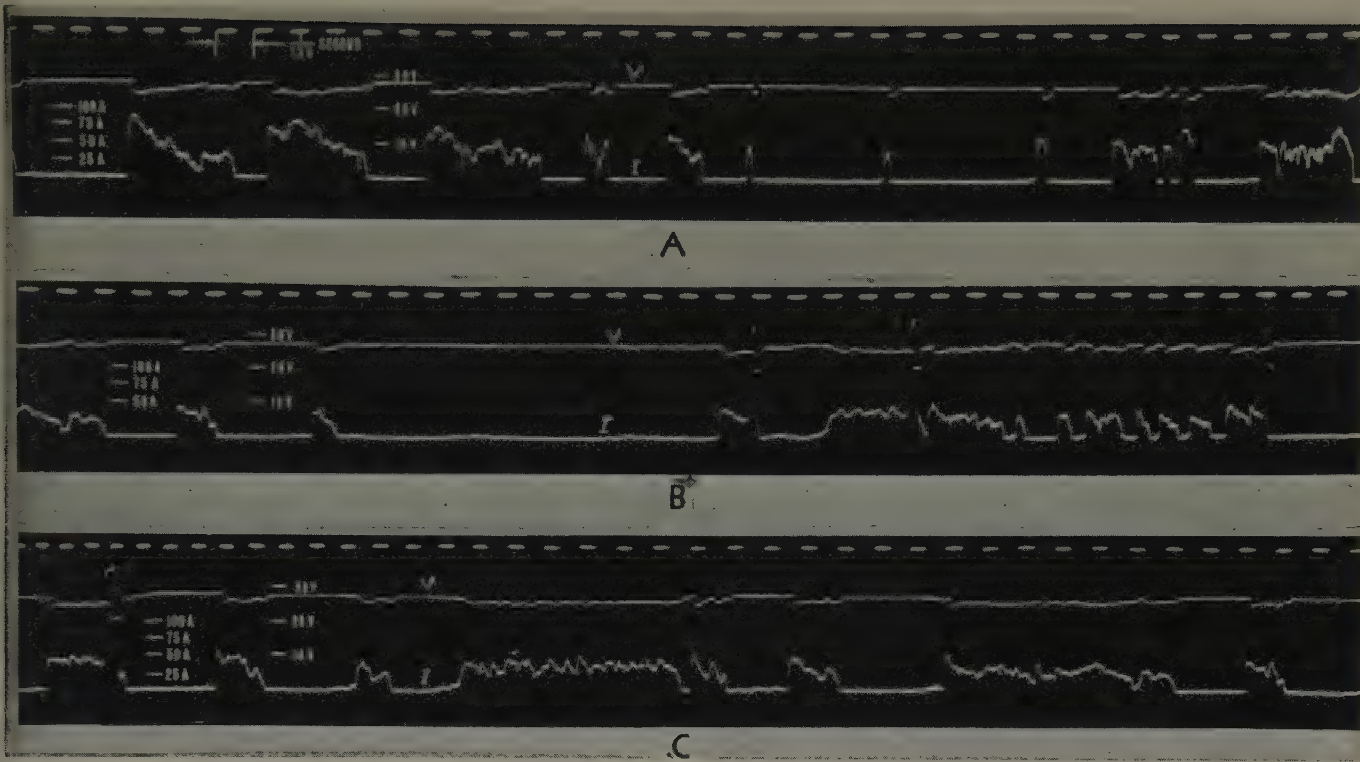

Figure 5. Oscillograms showing the characteristics of typical arcing faults using one 30-volt 400-ampere aircraft generator. The ground plane was 0.050-inch aluminum

A—15 feet of AN size 10 cable *B and C—10 feet of AN size 16 cable*

tics of arcing faults, the following experimental arrangement was used.

The physical arrangement of the ground plane and the faulted conductor on a vibration table is shown in Figure 1. The associated circuit arrangement is shown schematically in Figure 2. In laboratory tests a vibration table frequency of 30 cycles per second and a displacement of 0.050 inch was used as an approximation of aircraft vibration. Brief surveys of the effect of varying frequency and displacement were made prior to selecting the aforementioned values. Vibration was applied vertically and horizontally with minor variations in fault characteristics. The data to be presented were accumulated using horizontal vibration.

SYSTEM CHARACTERISTICS

The steady-state and transient characteristics of the 30-volt aircraft generator[1] are given in Figure 3. These characteristics were taken at the point of application of the faults. It is apparent from these characteristics that the power source does influence the fault current though the variation is obscured by the variable nature of the arc resistance during the fault. To simplify the test program the oscillograms were taken without load or battery connected to the bus.

The generator supplying power for faults above 30 volts was excited by a controlled exciter having considerable time delay. The approximate steady-state and transient characteristics of this generator at the point of fault are given in Figure 4. Characteristics are given for 45, 70, 90, and 120 volts.

ARCING FAULT CHARACTERISTICS

For 30-volt systems, the nature of the arcing fault often results in intermittent arcing. As can be seen in Figure 5, the peak value of the current is limited by the circuit resistance. The normal arc current is considerably below this value and is determined by the arc resistance and the transient characteristics of the supply system. Visually, one has the impression that the arcing is continuous. The oscillogram shows conclusively that there is no current

Figure 6. Typical damage to cables by arcing faults at 30 volts

conduction for a large portion of the time. The nature of the damage done to cables by such faults can be seen in Figure 6. From Figure 6, it is apparent that the type of insulation does influence the arc. The damage to the insulation is due to heat conduction along the conductor from the arc. In burning, rubber insulation forms an enlarged, rigid, charred material that tends to prevent further contact between the ground plane and the conductor. Some of the plastic insulations exhibit a self-healing characteristic in that the plastic softens and may seal off the conductor during a period of nonconduction. The normal AN cable has the undesirable characteristic of forming a thin, brittle residue after burning. In the presence of vibration, this material is broken back from the end of the conductor tending to enhance the arcing fault.

On going to higher system voltages, two marked phenom-

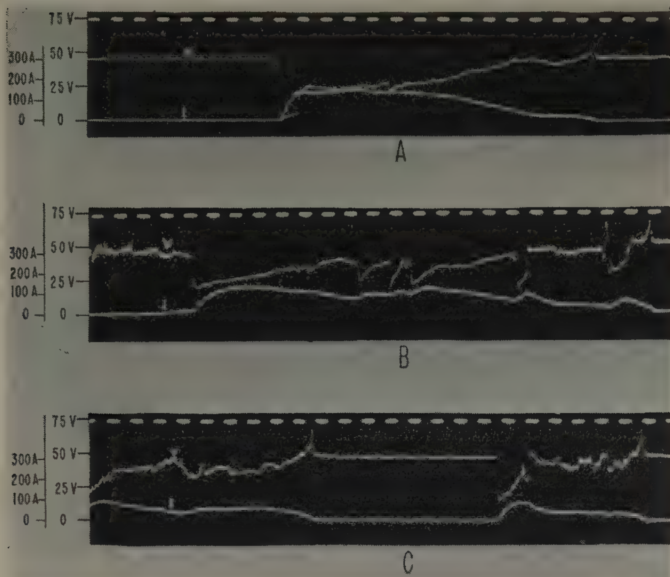

Figure 7. Oscillograms showing the characteristics of typical arcing faults using an unregulated 45-volt 200-ampere generator. The ground plane was 0.050-inch aluminum

A—10 feet of AN size 1/0 cable
B—10 feet of AN size 8 cable
C—10 feet of AN size 16 cable

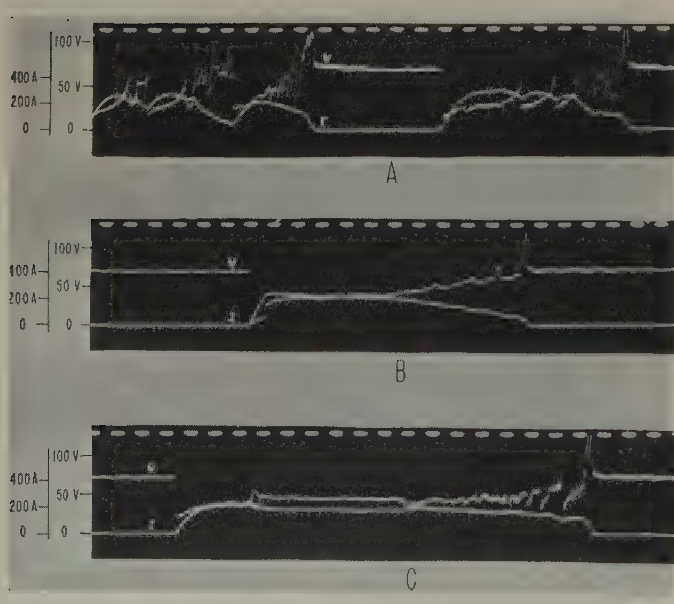

Figure 8. Oscillograms showing the characteristics of typical arcing faults using an unregulated 70-volt 200-ampere generator. The ground plane was 0.050-inch aluminum

A—10 feet of AN size 1/0 cable
B—10 feet of AN size 8 cable
C—10 feet of AN size 12 cable

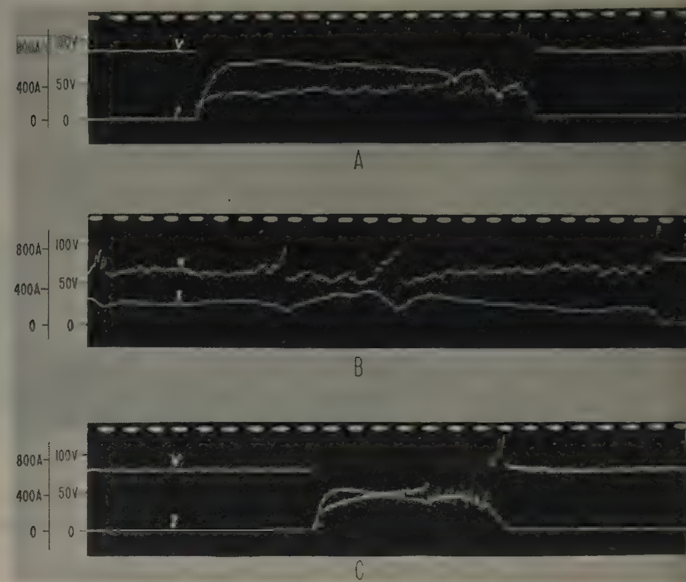

Figure 9. Oscillograms showing the characteristics of typical arcing faults using an unregulated 90-volt 200-ampere generator. The ground plane was 0.050-inch aluminum

A—10 feet of AN size 1/0 cable
B—10 feet of AN size 8 cable
C—10 feet of AN size 12 cable

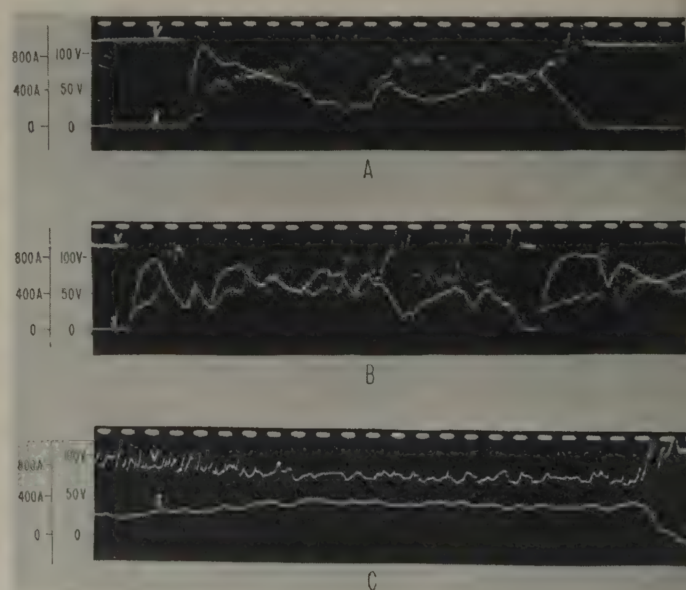

Figure 10. Oscillograms showing the characteristics of typical arcing faults using an unregulated 115-volt 200-ampere generator. The ground plane was 0.050-inch aluminum

A and B—10 feet of AN size 1/0 cable
C—10 feet of AN size 4 cable

Figure 11. Typical damage to cables by arcing faults at 115 volts

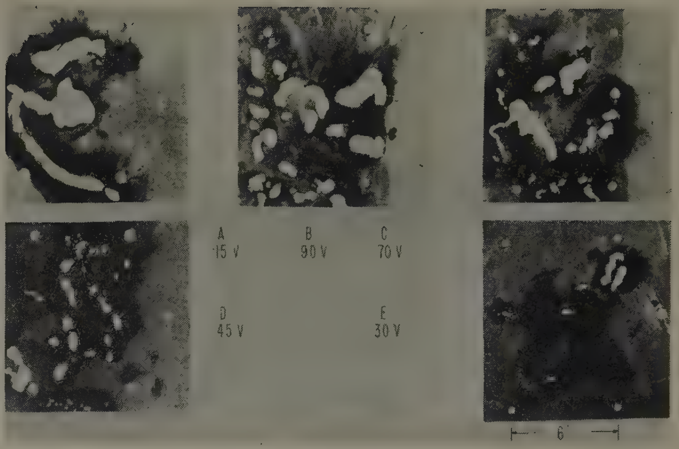

Figure 12. Typical damage to aluminum ground planes by arcing faults at various voltages. The ground planes were 0.050-inch aluminum

Power Source:
A, B, C, D—12- to 120-volt 200-ampere unregulated generator
E—30-volt 400-ampere regulated aircraft generator

ena are noticed. As would be expected, the arc is much more violent, causing considerably more damage. Between 30 and 40 volts, the arcs change from an intermittent nature to a continuous arc. Due to the extreme violence of the arc for 120-volt equipment, the ground plane may be burned back until the fault is cleared. However, since the conductor is exposed to continued vibration, wind load, or other action, it would re-establish the arc on contact with any grounded metal.

Typical oscillograms of faults at increased voltages are shown in Figures 7, 8, 9, and 10. It will be noted that the flow of current into the fault is more stable for the higher voltages indicating increased average power consumption in the arc. Damage to faulted conductors is indicated in Figure 11. The high power dissipation causes the insulation to be burned more severely adjacent to the fault than at lower voltages.

A comparison of the damage done to aluminum plates simulating the aircraft structure is given in Figure 12. It will be noted that slots are burned in the plates in many cases. This seems to be associated with the phenomenon of charred insulation breaking off under vibration as mentioned earlier. These plates are typical of the damage done by the various system voltages. Each plate was used for a number of tests at the particular voltage.

CONCLUSIONS

The premise that any fault endangering the safety of the aircraft must be cleared leads to these conclusions:

1. Arcing faults may not overload the individual circuit.
2. Structural damage and fire hazard resulting from arcing faults may be extensive.
3. System protection based on welded fault conditions is not adequate.
4. Differential protection, as now applied to generator circuits, is not easily adapted to the entire distribution system because of the increased weight and vulnerability.
5. Consideration must be given to the use of an ungrounded system to decrease the probability of encountering an arcing fault.

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Westinghouse to Build $6,000,000 Laboratory at South Philadelphia

Ground has been broken for a $6,000,000 steam and gas turbine development laboratory at the South Philadelphia (Pa.) Works of the Westinghouse Electric Corporation. Actual construction will begin late this summer and will take about 1 year to complete. It initially will conduct special research for the United States Air Force.

Steam and gas turbines and their components up to 15,000-kw capacity will be accommodated in the main test hall of the new research building. Three 8,000-horsepower axial-flow compressors for gas turbines will provide facilities for compressor development for gas turbines and the Air Force wind tunnel. Separate laboratories will be provided for hydraulic, heat exchange, mechanical, aerodynamic, combustion, and model shop activities.

The new laboratory powerhouse will include a huge boiler providing 150,000 pounds of steam per hour at a temperature of 900 degrees Fahrenheit. A reheater, used in conjunction with reducing values, will make available steam at any desired pressure up to 1,500 pounds per square inch and at a temperature ranging from 800 to 1,100 degrees Fahrenheit.

Electric Power Supply for a Large Chemical Plant

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THE A-C ELECTRIC power generation and distribution system of The Dow Chemical Company, Midland, Mich., represents the experience of a plant-wide a-c system that has grown from small beginnings in a period of 23 years. Also, being a chemical plant, many special problems peculiar to the chemical industry have been solved.

Generation at the Midland plant today is provided by several 2,400-volt and 13.8-kv generating units. These are supplemented by a connection with the Consumers Power Company, the whole scheme being a miniature of a public utility system.

The 13.8-kv system is a grounded neutral system, machines 6 and 14 being grounded through five 1/3-ohm resistors and machine 15 through a 4-ohm resistor. These resistors will keep ground-fault current down to 5,000 amperes, sufficient for rapid relay tripping but insufficient to cause excessive burning of machine laminations.

At Dow-Midland the electric power generated is a by-product of process steam use and, accordingly, the amount of electric power which can be generated cannot exceed that which can be stripped from the process steam load. The total cost of steam plus by-product power is less than the total cost of steam plus purchased power. It is apparent, therefore, that it is desirable to maintain as close a balance as possible between steam use versus power use.

Operating experience at Midland has shown that when there are tie lines in parallel between a pair of powerhouses and where a synchronizing bus is available, the tie lines should be connected from synchronizing bus to synchronizing bus rather than from generator bus to generator bus. Otherwise, under certain conditions there will be differences in reactances between the tie lines in parallel which will not allow full use of rated capacity.

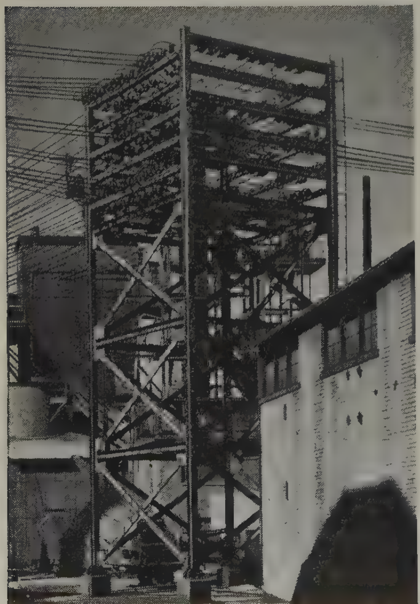

Figure 1. Tower J showing open construction

Figure 2. Cable risers at south powerhouse

The plant distribution system is a radial system. In general the latest additions consist of 500,000-circular-mil aerial cables carrying power at 13.8 kv from the powerhouse bus sections to centers of load areas. At the load centers, 13.8/2.4-kv transformers are installed consisting of 6,000/-7,500-kva 3-phase oil-filled transformer banks connected to indoor 2,400-volt switchgear assemblies.

The system is radial, but since many of the processes served by the 2,400-volt substations are critical and cannot be interrupted for long, a secondary selective feature is provided by normally open 2,400-volt ties between pairs of substations. By sizing the 13.8-kv cable for 10,000-kva emergency rating and by using transformers rated 7,500 kva continuous with fan cooling to serve a normal 5,000-kva load, provision has been made for emergency operation of two substations from a single 13.8-kv feeder and transformer.

The plant originally used only open overhead construction, but later 3-conductor bronze interlocked armored aerial cable was used for the newer 13.8-kv lines. The aerial cable has advantages in reliability and saving of space which justify its use. Note the space required to get nine 2,400-volt open circuits away from a switchhouse, see Figure 1, compared to the space required to get eight 13.8-kv aerial cables away from one of the powerhouses, see Figure 2.

Digest of paper **52-80**, "Electric Power Supply for a Large Chemical Plant—Dow Midland," recommended by the AIEE Committee on Industrial Power Systems and approved by the AIEE Technical Program Committee for presentation at the Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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A Special Dynamometer for Testing Small Motors

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Based on the principle that output torque is equal and opposite to the reaction on the motor frame regardless of the source of external shaft loading, this dynamometer can make accurate measurements on the performance of motors too small to be tested by the usual methods.

THE TESTING OF small motors is generally difficult because of the low torque available and the loading effect of most measuring devices. The eddy-current brake is ineffective at low speed and imposes additional static burden upon the motor bearings which may influence materially the measured output of very small motors. At higher speed the eddy-current disk imposes an appreciable windage load which cannot be evaluated, thus impairing the accuracy of measurement. Prony brakes and other similar common types are impractical to construct and use in the very small size.

Induction motors frequently have harmonics present in the air-gap flux and manifest this by dips or general fluctuations in the torque-speed curve. Two striking cases of harmonic torques are represented in Figure 1 which was prepared from actual test data. It is readily apparent that one of the conditions depicted would cause the motor to lock at a subsynchronous speed. For both cases having substantial harmonic torque, it was virtually impossible to obtain with conventional means any reliable torque readings in the region of maximum dip. The eddy-current brake and the prony brake are of little value in situations such as these.

In some applications it is necessary to evaluate the performance of motors outside of the normal motor speed range. For example, it is helpful to have performance information on servo motors in both the generator and braking ranges of operation. Koopman has shown[1] that the performance of 2-phase servo motors for all conditions of operation may be computed from the torque-speed curve obtained with balanced, rated voltages on both phases. This curve should cover the range from +200 per cent to −200 per cent of synchronous speed. Since a motor is limited to operating under its own power in its normal speed range, it is necessary to have an external source of rotational power if such braking and generator characteristics are to be measured. Although the dynamometer here discussed was originally developed for testing of commercial motors, it was improved in the second model which was built primarily for the testing of servo motors. In this field it possesses capabilities not available in dynamometers of usual design.

In the course of commercial development it is frequently desirable or necessary to know the load characteristics of devices operated by small motors. For example, the fan blades used on ordinary commercial and domestic fans may require relatively little power but must be matched the motors with which they to are to be operated. In the case of gear trains and other devices, which are to be interposed between a motor and its ultimate load, there is obvious value in the knowledge of the loading imposed by such equipment. The dynamometer here discussed is adaptable to measurements such as these without accessories or modification.

CONSTRUCTION OF SPECIAL DYNAMOMETERS

OVER A PERIOD of several years there has been evolved a dynamometer on which most measurements already discussed can be made. The design is based upon the principle that output torque is equal and opposite to the reaction upon the motor frame, regardless of the source of external loading on the shaft. The motor under test is mounted in a pivoted cradle arranged to permit the measurement of reaction torque. The first unit constructed is

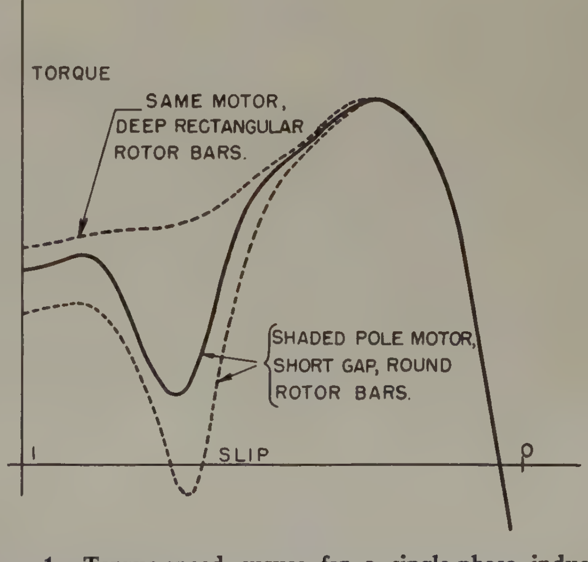

Figure 1. Torque-speed curves for a single-phase induction motor with pronounced third-harmonic influence

Full text of paper **52-147**, "A Special Dynamometer for Testing Small Motors," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Not scheduled for publication in AIEE *Transactions*.

S. H. Van Wambeck is with the Knapp-Monarch Company, St. Louis, Mo., and **W. A. Stein** is with the United States Naval Postgraduate School, Monterey, Calif.

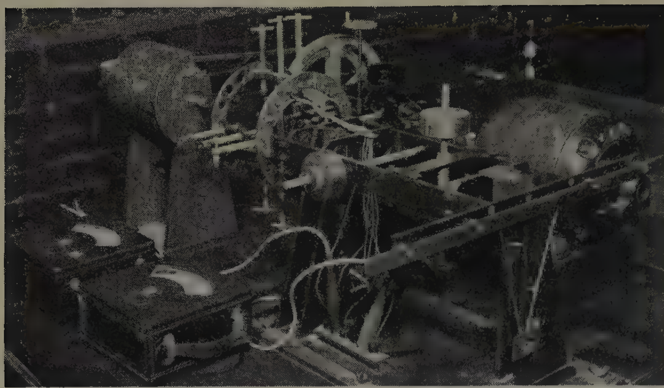

Figure 2. The first model dynamometer and auxiliary components

provided with a 20-inch scale beam and slideable weights, as shown in Figure 2. A long pointer is used to identify accurately the balance position. This arrangement is advantageous in that the effects of leads, off-center pivoting, and so forth, are minimized and the range of torques which can be measured is quite large, ranging from 2 inch-ounces maximum with the lightest weight up to 150 inch-ounces maximum for the highest range. Since the beam must be rebalanced for each speed setting, two operators must be available if highest accuracy is desired. The second model uses a pendulum for the direct measurement of torque. As a result there is a nonuniform scale, with unit distance representing smallest increments of torque around the zero point. This is due to the fact that the pendulum torque varies as the sine of the deviation angle. Three calibrated weights are provided for the pendulum arm: one of 1 ounce, one of 2.5 ounces, and one of 5 ounces. These pendulous weights are made in such a way that they may be adjusted up and down on the pendulum arm and will lock into indentures located 1, 2, and 3 inches from the center of rotation. In this manner, it is quite simple to extend the torque scale from 1 inch-ounce to 21 inches-ounce, even while the dynamometer is being operated. This equipment can be operated more readily by one person but may suffer some loss in accuracy due to the unpredictable resisting torques in the leads from the cradle to the frame.

On both models the leads are extremely flexible and are suspended essentially along the rotational axis of the cradle. In the first model the leads are slack and contribute no measurable amount to the torque on the pivoted member. In the second model the leads are placed under some longitudinal tension but again there is very little contribution from them to the torque. They are brought out through the bore of the hollow shaft to which the mounting cradle is connected.

Two sets of movable weights are provided on both dynamometers to adjust the balance and sensitivity. A horizontal arm with opposed adjustable weights makes possible the establishment of initial static balance. A vertical arm with opposed weights permits some shift in the center of gravity of the pivoted mass and corresponding control of the sensitivity. When measurements at very low torque level are to be made, the effective center of gravity must be raised nearly to coincide with the pivot centers so there is little pendulum effect and correspondingly high sensitivity.

The pivoted cradle or cage originally was mounted on a knife edge arrangement but difficulty was experienced with this mounting and it was changed to ball bearings. The bearings selected are uncaged and nonsealed and were picked because of the relatively large ball diameter. The mounting brackets are arranged to shroud the bearings very closely but so as not to permit sliding or rubbing contact between stationary and moving elements to introduce friction. Vibration common to the operation of the dynamometer has been found adequate to overcome the small friction in the bearings. Although others have used oppositely rotating outer cages for the ball bearings to overcome frictional effects,[2] the results with this equipment indicate that ball bearings of the type employed give adequate freedom of motion if they are kept thoroughly clean.

The loading device is essentially a variable speed drive which fixes the speed of rotation at the value for which a torque reading is desired. It is sufficiently powerful to maintain the selected speed despite the motor action tending to change it. In both variations of the dynamometer a 1/3-horsepower motor is used to drive a variable-speed hydraulic transmission. The hydraulic units are reversible and will operate at any speed up to 1,800 rpm. A selection of pulleys and belts makes possible the choice of any operating speed up to approximately 12,000 rpm at the auxiliary shaft which couples to the motor under test. The physical arrangement of the second design is shown clearly in Figures 3 and 4. The auxiliary shaft on the loading device is aligned accurately with the rotational center of the cradle and is at a distance convenient for coupling to the motors mounted in the cradle.

Since the speed is determined by the variable-speed external drive, there is adequate power to operate a conventional tachometer. Various types of electric and mechanical tachometers have been used and in the case of some slow-speed measurements, it has been found necessary to use a revolution counter and stop watch. The fact that the speed may be set and will remain essentially constant over

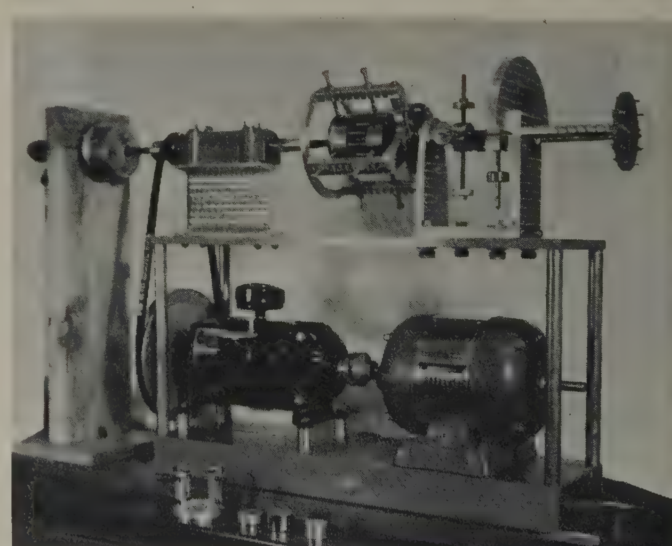

Figure 3. The second model of the dynamometer and auxiliary components

an appreciable period while torque is measured and meter readings are recorded is a distinct asset in the laboratory.

In motor test service the motor is mounted in the cradle and is centered with respect to the axis of rotation. A short coupling shaft between the motor and the spindle of the loading unit permits some misalignment without introducing error. However, it is very important that the alignment be precise for measurements on the smallest motors where binding in the coupling will influence materially the observed torque readings. Thick-walled rubber tubing makes convenient flexible couplings for small motors but conventional couplings with set screws, or keys, may be used with heavier equipment.

A convenient accessory to aid in centering the motor is a dial indicator which can be mounted on the auxiliary shaft of the loading device and arranged to rotate with it. As this indicator is rotated about the projection of the motor shaft, it makes possible the rapid, accurate centering of the motor in the cradle. This operation is similar to the centering of work in an independent chuck of a lathe.

OPERATION

FOR NORMAL TESTS with the motor operating in its standard range of speed, the loading device is set to rotate in the same direction as the motor and the torque is read directly either on the beam or by deflection of the pendulum. The torque measured under these conditions is considered positive if the output of the motor exceeds the friction and windage. This is depicted in Figure 5 in the zone identified as "motor range."

The friction and windage of the de-energized motor or the power input to any other device can be evaluated readily by driving at the speeds of interest with the external power source and measuring the respective torques. The friction and windage for a motor, for example, can be measured for both directions of operation to permit the plotting of load curves such as those identified as T_F in Figure 5.

Outside of the normal motor speed range, torque measurements are made in the same manner as for standard motor tests but the observed torques will be reversed in some cases. No particular precautions must be observed in making such readings, but care must be exercised in correcting the observed torques for friction and windage to obtain the internal torques. The sense of the various torques is represented in Figure 5, which may serve as a guide for the corrections necessary to the various ranges of operation.

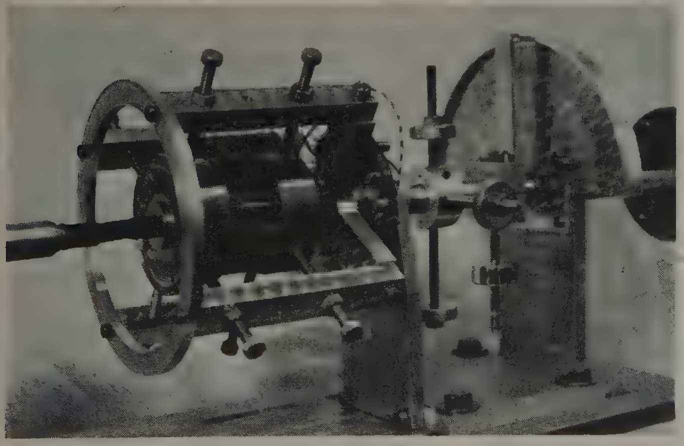

Figure 4. A close-up of a 2-phase servo motor clamped in the cradle for test

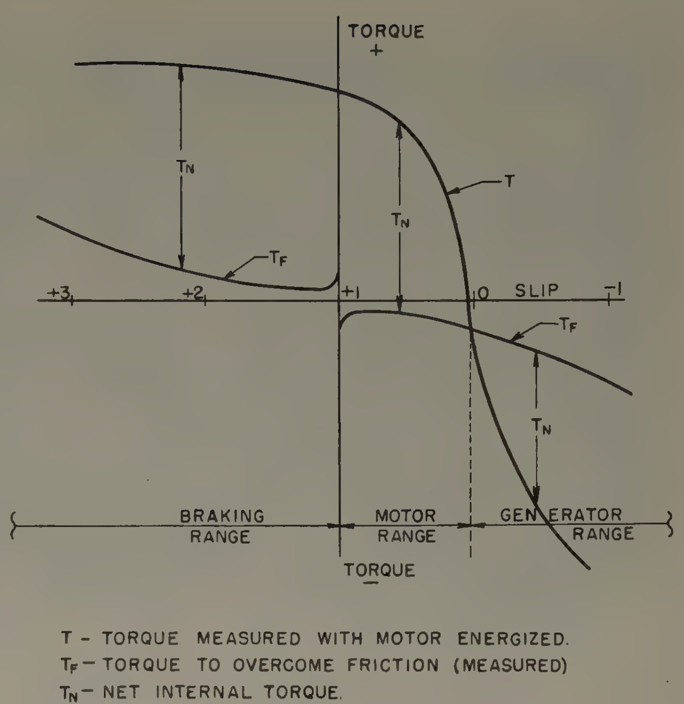

Figure 5. Typical characteristics of a 2-phase induction servo motor

Experience with the first design has demonstrated that the amount of centering moment from pendulum effect required for stability is proportional to the maximum torque to be measured. With the least usable pendulum moment the dependable sensitivity is the order of 0.02 inch-ounce while the maximum readable torque is 2 inch-ounces. Hence, the sensitivity is the order of one per cent of the maximum torque for this range. The same percentage will apply closely to all higher ranges where the greater torque capacities are matched by lower sensitivities. Damping by eddy currents or viscous means possibly would improve the stability, reduce the amount of centering moment required from the pendulum, and increase the sensitivity. However, the sensitivity now available is adequate for most purposes so the added complication in a frictionless damper scarcely is justified.

The second model depends on a pendulum for torque measurement so there is no way to improve sensitivity independent of change in capacity. The percentage accuracy for optimum initial balance is also essentially one per cent. A damper could not improve this figure. A smaller and lighter mounting cradle for accommodating motors of less than 2 inches in diameter can be substituted for the large one. Reduced bearing friction with the smaller static load improves sensitivity when testing very small units.

REFERENCES

1. Operating Characteristics of 2-Phase Servo Motors, **R. J. W. Koopman.** AIEE *Transactions*, volume 68, part I, 1949, pages 319–28.

2. A High Precision Dynamometer for Small Motor Measurements, **J. E. Duff.** AIEE *Transactions*, volume 66, 1947, pages 1344–8.

Details of Technical and Social Program Released for Summer General Meeting

Daily luncheons will be a novel feature of the AIEE Summer General Meeting in Minneapolis, Minn., June 23–27. They will enliven a full week of technical sessions, varied and far-flung inspection trips, and diversified entertainment. A social event has been planned for each intervening evening, and something of interest is scheduled in conjunction with each luncheon.

Technical sessions will deal with computing devices, electronics, electromedical problems, instruments and measurements, magnetic amplifiers, and communications. Other divisions have scheduled sessions on power systems and equipment, feedback control, electrochemical applications, mining and metal industry, and land transportation. Two sessions will be devoted to District Prize Papers from Student Branches. In addition there will be sessions on management, safety, and a Section forum, plus a conference of all the Section delegates.

A conference type of panel discussion will consider "Management of Engineering Activity." This session, under the chairmanship of W. R. Hough, Reliance Electric and Engineering Company, will present three members of the panel discussing various aspects of the problem: T. M. Linville, General Electric Company; C. L. Brisley, Wolverine Tube Division, Calumet and Hecla Consolidated Copper Company; and E. W. Seeger, Cutler-Hammer, Inc. The session will be sponsored by the AIEE Committee on Management, of which C. J. Beller is chairman.

GENERAL SESSION AND LUNCHEONS

The program for the week will open with the annual meeting at 10:00 a.m., Monday, in the main ballroom of Hotel Nicollet where the new AIEE president will be installed and President F. O. McMillan will deliver an address.

A feature of the session will be the presentation of the Lamme Medal to Arthur E. Silver of Upper Montclair, N. J. The medal is being presented to Mr. Silver "for his pioneering of rural electrification by designing the simplified farm-type transformer combined with high voltage, long span, and common neutral line construction."

Mr. Silver retired from Ebasco Services, Inc., in 1948. The studies he undertook there led to the development of a farm transformer and accessories that lowered the cost of electric transmission in rural areas, and made electricity available to many of the nation's farms.

Dr. Lawrence R. Hafstad, of the Atomic Energy Commission, will speak at the Wednesday luncheon. Dr. Hafstad, a native of Minneapolis, is director of the Division of Reactor Development, a post he has held since its establishment in 1948. This division has charge of the practical application of atomic energy for generation of power for propulsion of ships and aircraft. Dr. Hafstad's subject will be "The Reactor Development Program of the Atomic Energy Commission."

On Monday, Dr. James L. Morrill, President of the University of Minnesota, will discuss "Industry, Ideas, and Ideals." Dr. Morrill, an outstanding public speaker, has been President of the University of Minnesota since July 1945. Previously he was President of the University of Wyoming and Vice-President of Ohio State University.

Institute prizes for the best technical papers in the Great Lakes District will be presented to the winners at the luncheon, Tuesday noon. As chairman of the Prize Awards Committee, J. R. North, District Vice-President, will make the presentations.

An interesting discourse on "American Engineering—Its Centennial and Future" will be given at noon on Thursday by T. G. LeClair, past president of the AIEE. The talk will cover some of the contributions that engineering has made to America's greatness. It will give a few of the reasons why the United States, with only small proportions of the world's area and population, has about half of the world's automobiles, refrigerators, and other labor-reducing and comfort-giving products. It will conclude with some of the newer problems that challenge the younger men entering the profession.

Trophies and prizes won in the various sports and prize meet contests during the week of the meeting will be awarded at the Friday luncheon. R. G. Lynn, Chairman of the Sports and Prize Meets Committee, will present the prizes.

INSPECTION TRIPS

Sixteen inspection trips have been arranged to industries and points of interest in and around the Twin Cities. In several plants to be visited security regulations are in force, and persons expecting to take these trips should come prepared with passports, copies of birth certificates, naturalization papers, or similar evidence of citizenship. Tickets will be available at the ticket desk,

Early hydroelectric plant at St. Croix Falls, Wis., where a stop will be made during the Summer General Meeting

Future AIEE Meetings

Summer General Meeting (*page 552*)
Hotel Nicollet, Minneapolis, Minn.
June 23–27, 1952
(*Final date for submitting papers—closed*)

Pacific General Meeting
Hotel Westward Ho, Phoenix, Ariz.
August 19–22, 1952
(*Final date for submitting papers—closed*)

AIEE Participation in Centennial of Engineering
Congress Hotel, Chicago, Ill.
September 10–12, 1952
(*Final date for submitting papers—June 10*)

Fall General Meeting
Jung Hotel, New Orleans, La.
October 13–17, 1952
(*Final date for submitting papers—June 13*)

Middle Eastern District Meeting
Commodore Perry Hotel, Toledo, Ohio
October 28–30, 1952
(*Final date for submitting papers—July 30*)

AIEE Special Technical Conference on Electrically Operated Recording and Controlling Instruments (*page 572*)
Benjamin Franklin Hotel, Philadelphia, Pa.
November 17–18, 1952
(*Final date for submitting papers—July 17*)

and should be purchased early, as some of the trips are for limited numbers.

General Mills, Minneapolis (Monday, June 23, 2:00 to 4:00 p.m. Tickets, 75 cents). One of Minneapolis' largest flour mill groups will be visited. The tour includes milling, research, and packaging facilities and a pilot plant. Products manufactured include flour, well-known breakfast cereals and baking products, animal feeds, and electric appliances. The firm engineers and develops the packaging of its products. Using one-tenth of the farm wheat crop annually, this is the largest flour milling organization in the world.

Minnesota Mining and Manufacturing Company, St. Paul (Tuesday, June 24, 8:30 a.m. to 1:30 p.m., including luncheon. Restricted to citizens. Tickets, $1.25). Members will see the steps in the manufacture of tapes, from the handling and processing of raw rubber into solution through calendering, coating, and slitting operations yielding the finished tape products. A wide variety of tapes and abrasive papers is manufactured. Familiar ones are "Scotch" cellulose tape, and "Scotchlite" reflective sheeting used for highway and advertising signs; others are rubberized masking and electrical tapes. Magnetic sound-recording tape made here will be demonstrated in the course of the trip. A stop will be made at the research laboratory for a demonstration of recent developments of fluoro-chemical carbon compounds of importance to the electrical field.

Riverside Steam Plant of the Northern States Power Company, Minneapolis (Tuesday, June 24, 9:00 a.m. to 12:00 noon. Tickets, 75 cents.) The largest generating plant on the Northern States system, this station produces an annual output of over 1 billion kilowatt-hours. Seven turbogenerator units installed from 1915 to 1950 utilize steam, three at 225 pounds per square inch and 600 degrees Fahrenheit, two at 400 pounds per square inch and 750 degrees Fahrenheit, and two at 900 pounds per square inch and 900 degrees Fahrenheit. Coal is the principal fuel, with gas on a standby basis. River water from the Mississippi, circulated at 320,000 gallons per minute, cools the condensers. The station output is through underground cables at 13,000 volts and via overhead transmission lines at 115,000 volts.

Sightseeing Tour of the Twin Cities, Minneapolis and St. Paul (Tuesday, June 24, 2:00 to 4:30 p.m. Tickets, $1.00). More than 160 parks covering over 6,000 acres grace the Twin Cities. They include nine large lakes and many more small ones, and picturesque bluffs along the banks of the Mississippi. The ride among these, through fine residential sections and past the Minnesota State Capitol, universities, and other centers of interest, will include a visit to the famous Falls of Minnehaha.

Northwest Airlines' Overhaul Base, St. Paul (Tuesday, June 24, 2:00 to 4:30 p.m. Tickets, $1.00). This facility is situated at Holman Field in St. Paul. Visitors will be taken through the hangars where all major maintenance and overhaul work on ships of the Northwest fleet is done. These ships, *DC-4*'s and Boeing 2-deck Stratocruisers, are completely disassembled and renovated here on a periodic maintenance schedule. Engines are disassembled, rebuilt, and tested, and structural parts of the airplanes are repaired or replaced as occasion requires. The tour will give a first-hand look at what is being done to keep flying safe.

The Reeves analogue computer will be seen during inspection of the Institute of Technology, University of Minnesota

Institute of Technology, University of Minnesota, Minneapolis (Wednesday, June 25, 9:00 a.m. to 12:00 noon. Tickets, 75 cents). The ten engineering buildings located on the main campus provide facilities for engineering students. A research program is conducted, with sponsored funds totalling over $1,600,000 in addition to funds provided directly by the university treasury. Projects under way of especial interest to electrical engineers are conformal mapping studies, research on differential equations, a computing center equipped with a Reeves analogue computer, a-c machinery and electron-tube laboratories, studies of amplifier and conductor noise, and construction of a linear accelerator. Members will have opportunity to see as many of these activities as time will permit.

Lightning and Transients Research Institute, Minneapolis (Wednesday, June 25, 9:00 to 11:00 a.m. Tickets, 75 cents). This is a nonprofit enterprise sponsored by the Armed Forces and engaged in making fundamental studies of lightning with particular regard to aircraft and its protection. Visitors will be shown samples of the effects of lightning damage and demonstrations of protective methods. They will witness spectacular demonstrations of the high-voltage apparatus used, which can produce lightning strokes with a crest value of 9,000,000 volts and current surges of 250,000 amperes.

KSTP Radio and Television Station, Minneapolis (Wednesday, June 25, 2:00 to 4:00 p.m. Tickets, 75 cents). Radio station *KSTP* is a National Broadcasting Company independent affiliate broadcasting station, equipped for amplitude and frequency modulation and television broadcasting. The station has mobile facilities for local news coverage via television pickup truck units, and also is linked to the Atlantic and Pacific Coast systems by the Bell System video circuits.

Visitors will see the film projection system, transmitter control room, and transmitting equipment for pictures and for amplitude- and frequency-modulation sound programs. The television camera equipment will be demonstrated to the members.

Rosemount Research Center, University of Minnesota, Rosemount (Wednesday, June 25, 2:00 to 5:00 p.m. Tickets, $1.25). Visitors to Rosemount will see a huge research center working in various fields of activity. Major work here is in the field of aeronautics. A continuous-flow supersonic wind tunnel, a 36- and 15-inch free jet injector tunnel, two supersonic blow-down tunnels, and a transonic wind tunnel may be visited, and a tour taken through laboratories dealing in electronics and in problems of instrumentation.

St. Anthony Falls Hydraulics Laboratory, Minneapolis (Thursday, June 26, 8:00 to 11:00 a.m. Tickets, 75 cents). The hydraulics laboratory is operated by the University of Minnesota. Located along the Mississippi River and adjacent to natural waterfalls, it has adequate flow and a high natural head for hydraulics testing and experimentation. Models, such as a scale model of a portion of the Mississippi River and glass-sided channels, will be seen simulating actual hydraulic operations to permit studies of erosion, turbulence, and pressure fluctuations.

Aero Division, Minneapolis-Honeywell Regulator Company, Minneapolis (Thursday, June 26, 9:00 a.m. to 12:00 noon. Restricted to citizens. Tickets, 75 cents). This plant, with more than 600 engineers, is devoted exclusively to the engineering and manufacture of aeronautical controls. The tour will include views of the gyro assembly room, electronic equipment assembly, test facilities for radio noise, vibration, hy-

(*Continued on page 556*)

Tentative Technical Program

Summer General Meeting, Minneapolis, Minn., June 23-27

Monday, June 23

10:00 a.m. Annual Meeting

1. Report of Board of Directors. H. H. Henline, Secretary
2. Report of Treasurer. W. I. Slichter
3. Report of Committee of Tellers on:
   (*a*). Votes for nominees for AIEE offices
   (*b*). Proposed Constitutional amendments
4. (*a*). Introduction of, and presentation of President's badge to, D. A. Quarles
   (*b*). Response by Mr. Quarles
5. Presentation of Lamme Medal to Arthur E. Silver, retired, Ebasco Services, Inc., New York, N. Y.
   (*a*). The Establishment of the Medal. A. H. Kehoe, Chairman, Lamme Medal Committee
   (*b*). The Career of the Medalist. Clay C. Boswell, Vice-President and Assistant General Manager, Minnesota Power and Light Company
   (*c*). Presentation of the medal and certificate by President F. O. McMillan
   (*d*). Response by Mr. Silver
6. Any other business that may be presented
7. Address by President F. O. McMillan

2:00 p.m. Transmission and Distribution

52-176. Transient Fault Current and Voltage Recovery Characteristics of Distribution Systems. *Joint Subcommittee on Distribution Circuit Recovery Voltages*

52-177. A Passive Compensator for Voltage Flicker. *P. A. Cartwright*, University of Minnesota

52-178. Some Observations on the Economic Benefits in Going From One System Voltage Level to a Higher System Voltage Level. *D. K. Blake*, General Electric Company

52-175. Lightning to the Empire State Building, III. *J. H. Hagenguth, J. G. Anderson*, General Electric Company

2:00 p.m. Computing Devices

52-179—ACO.* A Contribution to the Design of Binary Counters. *G. R. Lang, L. L. Luke, D. K. Ritchie*, Ferranti Electric Ltd.

CP. ERA Shaft-Position Analogue-to-Digital Converter.** *G. W. Lund*, Engineering Research Associates

52-180. Digital-to-Analogue Shaft-Position Transducers. *S. J. O'Neil*, Air Force Cambridge Research Center

52-181. DINA, A Proposed Digital Network Analyzer. *C. Leondes, M. Rubinoff*, University of Pennsylvania

52-162. Catalogue of Digital Computer Designs. *J. H. Felker*, Bell Telephone Laboratories, Inc. Presentation by title only for discussion

2:00 p.m. Relays

52-182. Ground Fault Relay Protection of Transmission Lines. *J. L. Blackburn*, Westinghouse Electric Corporation

CP. Backup Protection of Transmission Lines.** Report of *Project Committee on Transmission-Line Protection*

52-183. Power-Line Carrier for Relaying and Joint Usage—II. A Survey of Modern Power-Line Carrier Systems. *G. W. Hampe, B. W. Storer*, Commonwealth Edison Company

CP. Performance of Overcurrent Relays on Cold Load Restoration.** *O. Ramsaur*, Pennsylvania Power and Light Company

52-184. Selecting A-C Overcurrent Protective Device Settings for Industrial Plants. *F. P. Brightman*, General Electric Company. Presentation by title only for discussion

* **ACO:** Advance copies only available; not intended for publication in *Transactions*.

** **CP:** Conference paper; no advance copies are available; not intended for publication in *Transactions*.

Tuesday, June 24

9:30 a.m. Sections Forum

9:30 a.m. Transmission and Distribution

52-188. Sleet Melting Practices—Niagara Mohawk System. *H. B. Smith, W. D. Wilder*, Niagara Mohawk Power Corporation

52-189. Sleet Thawing Practices of the New England Electric System. *C. P. Corey, H. R. Selfridge*, New England Power Company; *H. R. Tomlinson*, New England Power Service Company

52-187. 42 Years' Experience Combating Sleet Accumulations. *A. N. Shealey, K. L. Althouse, R. N. Youtz*, Pennsylvania Water and Power Company

52-186. Ice Melting and Prevention Practices on Transmission Lines. *V. L. Davies, L. C. St. Pierre*, Public Service Company of Northern Illinois

52-185. Sleet Melting on the American Gas and Electric System. *S. C. Bartlett, C. A. Imburgia, G. H. McDaniel*, American Gas and Electric Service Corporation

9:30 a.m. Transformers

52-156. Relation of Transformer Design to Fire Protection. *E. D. Treanor, L. C. Whitman*, General Electric Company. Presentation by title only for discussion

52-159. Dielectric Measurements on New Power Transformer Insulation. *W. L. Teague, J. H. McWhirter*, Westinghouse Electric Corporation

52-190—ACO.* 1,100,000-Kva Short-Circuit Transformer in the New High-Capacity Switchgear Testing Laboratory. *B. A. Cogbill*, General Electric Company

52-196. The Production Impulse Testing of Distribution Transformers. *E. D. Treanor, H. C. Stewart, J. E. Holcomb*, General Electric Company

CP. Common Insulation Problem.** *G. I. Comb*, Illinois Institute of Technology; *F. J. Vogel*, Allis-Chalmers Manufacturing Company

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—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

9:30 a.m. Instruments and Measurements

52-191. Computing Circuits and Devices for Industrial Process Functions. *A. J. Hornfeck*, Bailey Meter Company. Presentation by title only for discussion

52-163. The Fundamental Accuracy of Single-Phase 3-Wire Metering. *E. C. Wentz, A. J. Petzinger*, Westinghouse Electric Corporation

CP. Basic Theory and Experimental Verification of the Per Cent Limit Capacitance Bridge.** *T. J. Higgins, J. Joerger*, University of Wisconsin

CP. Complementary Galvanometer Deflection Constants and Steady-State Solutions of the Unbalanced Bridge.** *P. M. Andress*, Rubicon Company

CP. The Key to Quality—A Comprehensive Test Department.** *W. H. Clausen*, Minneapolis-Honeywell Regulator Company

9:30 a.m. Communication Switching Systems

52-201. Automatic Switching for Nation-wide Telephone Service. *A. B. Clark*, Bell Telephone Laboratories, Inc.; *H. S. Osborne*, American Telephone and Telegraph Company

52-202. Fundamental Plans for Toll Telephone Plant. *J. J. Pilliod*, American Telephone and Telegraph Company

52-203. Nation-wide Numbering Plan. *W. H. Nunn*, American Telephone and Telegraph Company

52-204. Automatic Toll Switching Systems. *F. F. Shipley*, Bell Telephone Laboratories, Inc.

2:00 p.m. Sections Delegates Conference

2:00 p.m. Transmission and Distribution

52-171. Power Limits of Transmission Lines. *L. E. Saline*, General Electric Company

52-160. Accurate Computation of 2-Machine Stability. *R. D. Goodrich, Jr.*, Bureau of Reclamation

52-192. Tensorial Analysis of Integrated Transmission Systems, III. The "Primitive" Division. *G. Kron*, General Electric Company

52-193. Analysis of Losses in Interconnected Systems. *A. F. Glimn, L. K. Kirchmayer*, General Electric Company; *G. W. Stagg*, American Gas and Electric Service Corporation

2:00 p.m. Transformers

52-232—ACO*. Standard Basic Impulse Insulation Levels 450 Kv to 1,050 Kv Inclusive. *Joint AIEE-Edison Electric Institute-National Electrical Manufacturers Association Committee on Co-ordination of Insulation*

52-194. Impulse Testing of Power Transformers. *J. H. Hagenguth, J. R. Meador*, General Electric Company. Presentation by title only for discussion

52-195. New Apparatus Bushing With Improved Characteristics. *R. N. Anderson, D. L. Johnston*, General Electric Company

CP. A New Method of Obtaining Insulation Co-ordination of Transformers.** *W. C. Sealey, F. J. Vogel*, Allis-Chalmers Manufacturing Company

2:00 p.m. Instruments and Measurements

52-157. Electronic Recorder With Range and Precision Adequate for the Platinum Resistance Thermometer. *A. J. Williams, Jr.*, Leeds and Northrup Company. Presentation by title only for discussion

CP. Resistance Temperature Sensing Elements for Aircraft Gas Turbines.** *Finn Larson, Ralph Squiers*, Minneapolis-Honeywell Regulator Company

52-197. A Long-Distance Multipoint Telemetering System Using Teletype Transmission. *A. J. Hornfeck, G. R. Markow*, Bailey Meter Company

CP. An Electric Hydrometer of Small Dimensions.** *W. A. Brastad, L. F. Borchardt*, General Mills, Inc.

CP. Home Heating Control.** *John Wilson*, Minneapolis-Honeywell Regulator Company

52-241. Aircraft Radio Interference Measurements. *M. M. Newman, R. C. Schwantes, J. R. Stahmann*, Lightning and Transients Research Institute

2:00 p.m. Nonlinearities in Feedback Control Systems

52-198—ACO.* A Study of Amplifier Saturation and Magnetic Saturation in a Servomechanism. *Cornelius Leondes*, University of Pennsylvania

52-154. Sinusoidal Analysis of Feedback-Control Systems Containing Nonlinear Elements. *E. C. Johnson*, Bendix Aviation Corporation

52-199—ACO.* The Use of Nonlinear Feedback to Improve the Transient Response of a Servomechanism. *J. B. Lewis*, University of Tennessee

52-200—ACO.* Servomechanism With Dead-Time Lag and Distributed Lag by Root-Locus Method. *Yaohan Chu*, Massachusetts Institute of Technology

Wednesday, June 25

9:30 a.m. Safety

CP. The Electrical Engineer's Stake in Safety.** *H. F. Webb*, West Penn Power Company

CP. Safety Aspects of Grounding Portable Equipment.** *H. B. Whitaker*, Underwriters Laboratories, Inc.

CP. Electrical Aspects of Mine Safety.** *V. M. Sovick*, United States Steel Corporation

CP. Extinguishing Fires in Electric Equipment.** *J. E. Appel*, Commonwealth Edison Company; *J. A. Bono*, Underwriters' Laboratories, Inc.

9:30 a.m. Rotating Machinery

52-167. Torque of Reluctance-Type Magnetic Couplings. *F. W. Suhr*, General Electric Company. Presentation by title only for discussion

52-168. Simplified Measurement of Subtransient and Negative Sequence Reactances in Salient-Pole Synchronous Machines. *F. K. Dalton, A. W. W. Cameron*, Hydro-Electric Power Commission of Ontario. Presentation by title only or discussion

52-221. New Large Short-Circuit Testing Generators. *C. E. Kilbourne*, General Electric Company

52-222. Forces in Machine End Winding. *Dean Harrington*, General Electric Company

52-223. A New Theory of Hunting. *Gabriel Kron*, Genera Electric Company

52-224. Synchronous Machines With Rotating Permanent Magnet Fields, I. Characteristics and Mechanical Construction. *M. W. Brainard*, O'Keefe and Merritt Company

52-225. Synchronous Machines With Rotating Permanent Magnet Fields, II. Magnetic and Electrical Design Considerations. *Fritz Strauss*, O'Keefe and Merritt Company

9:30 a.m. Insulated Conductors

52-152. Artificial Cooling of Power Cable. *F. H. Buller*, General Electric Company

52-205—ACO.* Weathering and Crack Resistance of Black Polyethylene Wire and Cable Insulation. *W. A. Haine, E. F. Smith, N. R. Smith*, Union Carbide and Carbon Corporation

52-226—ACO.* Guide for Temperature Correlation in the Connection of Insulated Wires and Cables to Electric Equipment. *Project Committee on Temperature Correlation*

52-158. Rapid Measurement of the Thermal Resistivity of Soil. *V. V. Mason, M. Kurtz*, Hydro-Electric Power Commission of Ontario. Presentation by title only for discussion

52-206. Surface Discharges From Cable Sheaths and Their Relation to Electric Shock. *E. W. Greenfield*, Kaiser Aluminum and Chemical Corporation. Presentation by title only for discussion

9:30 a.m. Basic Sciences

CP. Influence of Atmosphere Upon Contact Transients in a Simple Electric Circuit.** *O. E. Berg, H. E. Stauss*, Naval Research Laboratories

52-207. Subharmonics in a Series Nonlinear Circuit as Influenced by Initial Condenser Charge. *W. J. McKune, M. F. Brust*, University of Texas

52-240. A New Property of 2-Dimensional Fields. *A. D. Moore*, University of Michigan

52-208. Ultrathin Tapes of Magnetic Alloys With Rectangular Hysteresis Loops. *M. F. Littmann*, Armco Steel Corporation. Presentation by title only for discussion

52-227. Electrical and Physical Properties of IN-420—a New Chlorinated Liquid Dielectric. *A. J. Warner*, Federal Telecommunication Laboratories, Inc. Presentation by title only for discussion

9:30 a.m. Feedback Control Systems

52-161. The Analysis of Sampled Data Systems. *J. R. Ragazzini, L. A. Zadeh*, Columbia University

52-211—ACO.* Signal Component Control. *D. J. Gimpel, J. F. Calvert*, Northwestern University

CP. Stability Limits for Third-Order Servomechanisms.** *T. J. Higgins, J. G. Levinthal*, University of Wisconsin

CP. Progress Report on Terminology and Nomenclature for Feedback Control Systems.** *Terminology and Nomenclature Subcommittee*

52-239. Stabilization Templates for Servomechanisms. *O. J. M. Smith*, University of California. Presentation by title only for discussion

9:30 a.m. District Branch Prize Papers

2:00 p.m. Management of Engineering Activity—Panel Discussion

W. R. Hough, Moderator

Techniques for Managing Engineering Work. *T. M. Linville*, General Electric Company

Work Simplification as Applied to Engineering Work. *C. L. Brisley*, Wolverine Tube Company

Training for Engineering Supervisors. *E. W. Seager*, Cutler Hammer Corporation

2:00 p.m. Rotating Machinery

CP. Repeated Surge Testing of Motor Windings.** *N. Rohats*, General Electric Company

CP. Studies of Impulse Strength and Impulse Testing Problems on High Voltage Generators.** *G. L. Moses, R. J. Alke*, Westinghouse Electric Corporation

CP. A New Magnetic Amplifier Control for Magnetic Drives.** *D. W. Schlicker*

CP. Eddy Current Coupling Drives on the Longest Cement Kiln in the Western Hemisphere.** *E. H. Frederick*

2:00 p.m. Basic Sciences

52-212. Design of Unequal-Q Double-Tuned Transformers. *Sid Deutsch*, Polytechnic Research and Development Company, Inc.

CP. Analysis of a Comb Filter Using Synchronously Commutated Capacitors.** *W. R. LePage, C. R. Cahn, J. S. Brown*, Syracuse University

52-213. Solution of Electrical Engineering Problems by Southwell's Relaxation Method. *E. M. Grad*, Associated Electrical Industries, Ltd.

52-214. The Current Status of Dynamic Stability Theory. *F. E. Bothwell*, United States Naval Ordnance Test Station, Inyokern. Presentation by title only for discussion

52-215. Notes on the Design of Eccles-Jordan Flip-Flops. *Morris Rubinoff*, University of Pennsylvania. Presentation by title only for discussion

2:00 p.m. Industrial Power Systems

CP. Electric Power Relaying Is Important in Industrial Plants.** *S. S. Paist*, Rohm-Haas

CP. Philosophy of Electrical Designs for the Office Building of Tomorrow.** *C. C. Saunders*, E. I. DuPont de Nemours and Company

CP. Industry Response to Systems Neutral Grounding and Higher Voltage Lighting.** *S. C. Cooke*, General Electric Company

2:00 p.m. District Branch Prize Papers

2:00 p.m. Carrier Current

52-153. A Broad-Band Coupling Unit for Power-Line Carrier With Associated Potential Device. *J. A. Doremus, R. P. Crow, W. H. Freeman*, Motorola Inc.

52-217. New Method of Calculating Carrier Current Attenuation. *J. A. Becker*, Westinghouse Electric Corporation

52-218. Frequency-Shift Carrier-Current Equipment for Telemetering and Other Control-Type Functions. *R. W. Beckwith*, General Electric Company

52-219—ACO.* Application of Power-Line Carrier by Analogue Computer Studies. *J. D. Moynihan*, Westinghouse Electric Corporation

52-220. The Application of Power-Line Carrier Coupling Equipment to Typical Field Installations, I. *F. B. Gunter*, Westinghouse Electric Corporation

Thursday, June 26

9:30 a.m. Insulation

52-209. Field Studies of Generator Windings. *H. C. Marcroft*, Pennsylvania Water and Power Company

52-151. D-C Overpotential Testing Experience on High-Voltage Generators. *R. J. Alke*, Westinghouse Electric Corporation

CP. Testing Electrical Insulation of Rotating Machinery With High-Voltage Direct Current.** *G. L. Hill*, Pacific Gas and Electric Company

52-174. Interlaminar Insulation Test for Synchronous Machine Stators. *H. R. Tomlinson*, New England Power Service Company

52-166. The Re-examination of Temperature Standards for Electrical Insulation. *G. L. Moses*, Westinghouse Electric Corporation. Presentation by title only for discussion

9:30 a.m. System Engineering

CP. Synchronous Condenser Operation.** *C. R. Canady, J. H. Drake*, Southern California Edison Company

CP. Colfax Stability Tests.** Motion picture film by Duquesne Light Company

CP. Pool Accounting From an Operating Standpoint.** *M. J. Lacopo*, American Gas and Electric Service Corporation

CP. Emergency Dispatching Rules.** *E. E. George*, Ebasco Services, Inc.

CP. System Operation Without Communication.** *C. P. Corey*, New England Power Company

CP. Centralized Control of Electric Hot Water Heaters on a Rural Electrification Administration Distribution System.** *Lincoln Rietow*, Control Corporation; *H. A. Schimelfpenig*, Minnesota Valley Electric Cooperative

9:30 a.m. Electrical Techniques in Medicine

CP. Factors Concerned With the Medical Application of Ultra Sound.** *R. E. De Forest, M.D.*, American Medical Association

CP. Electrical Stimulation of Human Muscle.** *H. D. Bouman, M.D., Kathryn J. Shaffer*, University of Wisconsin

CP. A Practical Quantitative Electrokymograph.** *D. A. Kohl*, University of Minnesota

CP. Past and Present Forms of Apparatus for Physical Medicine.** *F. T. Jung, M.D.*, American Medical Association

9:30 a.m. Electrothermal Processes

CP. Electrical Supply for Arc Furnaces.** *R. L. Tremaine, R. F. Lawrence*, Westinghouse Electric Corporation

CP. Determination of Optimum Current in an Arc Furnace.** *D. R. Cochran*, General Electric Company

CP. Comparison Between European and American Electric Furnace Equipment.** *J. R. Lee*, Pittsburgh Lectromelt Furnace Corporation

CP. Melting and Refining of Modern Steels.** A sound film. Allegheny-Ludlum Steel Corporation

9:30 a.m. Mining Industry

CP. Modern Electric Equipment for Hulett Unloaders.** *W. C. Raube*, General Electric Company

CP. Electric Equipment Applications in Taconite Plants.** *W. H. Schwedes, A. F. Gettelman*, General Electric Company

CP.** The Elliott Oxygen Process. *Irving Roberts*, H. K. Ferguson Company

CP.** Application of Electric Controls and Machinery to Power Shovels. *W. J. Cherones*, Harnischfeger Corporation

2:00 p.m. Safety and Electrical Techniques in Medicine

CP.** Electric Defibrillation of the Heart. *W. B. Kouwenhoven*, The Johns Hopkins University

CP.** Physiologic Effects of Microwaves. *J. F. Herrick, F. H. Krusen, M.D.*, Mayo Clinic

CP.** Possible Industrial Hazards in the Use of Microwave Radiation. *H. M. Hines, J. E. Randall*, College of Medicine, State University of Iowa

2:00 p.m. Dielectrics

CP.** Fluorine Containing Gaseous Dielectrics. *G. Camilli, R. E. Plump*, General Electric Company

CP.** Properties of Some Fluorinated Liquids for Dielectric Uses. *N. M. Bashara*, Minnesota Mining and Manufacturing Company

CP.** Fluorine Containing Solids. *R. D. Rowley, C. B. Leape*, Westinghouse Electric Corporation

52-228. Impulse Dielectric Strength Characteristics of Liquid-Impregnated Pressboard. *T. W. Dakin, C. N. Works*, Westinghouse Electric Corporation. Presentation by title only for discussion

52-210. The Variation at Constant Density of the Dielectric Breakdown of Paper With Air Resistance. *Paul Cloke*, University of Maine; *K. K. Khandelwal*, Syracuse University. Presentation by title only for discussion.

2:00 p.m. Storage Batteries

CP.** Motive Power Batteries. *H. C. Riggs*, The Electric Storage Battery Company

CP.** Lead Calcium Cells. *J. H. Rittenhouse, H. E. Jensen*. C. and D. Storage Battery Company

CP.** Control of Dry-Disk Rectifiers for Battery Charging. *C. E. Hamann*, General Electric Company

CP.** Engine Starting. *E. A. Hoxie*, The Electric Storage Battery Company

2:00 p.m. Mining Industry

CP.** Iron Ore for the Future. *E. W. Davis*, representing American Institute of Mining and Metallurgical Engineers

CP.** Operating Experience With Heated Screens. *S. E. Erickson, M. Tanamachi*, M. A. Hanna Company

CP.** A Power Plant Suitable for a Taconite Project. *H. H. McMeen, N. A. Miller*, Sargent and Lundy.

Friday, June 27

9:30 a.m. Excitation Systems

52-229. Development of a Modern Amplidyne Voltage Regulator for Large Turbine-Generators. *W. A. Hunter, M. Temoshok*, General Electric Company

52-164. Effect of a Modern Amplidyne Voltage Regulator on Underexcited Operation of Large Turbine-Generators. *W. G. Heffron, R. A. Phillips*, General Electric Company

52-165. Operating Experience With Shaft-Driven Exciters in Air and Hydrogen. *F. M. Porter, H. B. Margolis*, American Gas and Electric Service Corporation

CP.** New Excitation Principles and Techniques. *J. E. Barkle, C. E. Valentine, J. T. Carleton*, Westinghouse Electric Corporation

CP.** Exciter Response. *H. W. Cory*, Allis-Chalmers Manufacturing Company

9:30 a.m. New Electronic Devices and Applications

CP.** An Engineering Progress Report on Reliable Tubes. *R. E. Moe*, General Electric Company

CP.** A 10-Stage Cold-Cathode Stepping Tube. *D. S. Peck*, Bell Telephone Laboratories, Inc.

CP.** Recent Advances in Industrial Electronics. *E. D. Cook*, General Electric Company

9:30 a.m. Land Transportation

52-169. Fifteen Years' Progress in the Design of Industrial Diesel-Electric Switchers. *R. W. Barrell*, General Electric Company

52-172. Electrification of Holland's Railway System. *A. H. Candee*, Westinghouse Electric Corporation

CP.** Get Off the Beaten Path. *C. M. Hines*, Westinghouse Electric Corporation

9:30 a.m. Magnetic Amplifier Circuits

52-233—ACO.* The Effect of Commutation on the Stability of Magnetic Amplifiers. *Masao Sakamoto*, Minneapolis-Honeywell Regulator Company

52-234. The Figure of Merit of Magnetic Amplifiers. *J. T. Carleton, W. F. Horton*, Westinghouse Electric Corporation

52-235. An Improved Magnetic Servoamplifier. *C. W. Lufcy, A. E. Schmid, P. W. Barnhart*, United States Naval Ordnance Laboratory

52-236. Saturable Reactors With Inductive D-C Load, I. Steady-State Operation. *H. F. Storm*, General Electric Company

52-237. A New Type of Magnetic Servoamplifier. *W. A. Geyger*, United States Naval Ordnance Laboratory

CP.** A New Magnetic Amplifier. *José Morois*, Lisboa, Portugal

52-238. Dynamic Hysteresis Loop Measuring Equipment. *H. W. Lord*, General Electric Research Laboratory. Presentation by title only for discussion

52-216. Types of Magnetic Amplifiers—a Survey. *J. G. Miles*, Engineering Research Associates, Inc. Presentation by title only for discussion.

2:00 p.m. Hydroelectric Systems

Round-Table Discussion on Power Generation. Any discussion pertaining to power generation will be welcomed at this session, particularly discussion pertaining to hydroelectric systems. Prepared answers will be given to questions sent in prior to the meeting, and there will be time for questions and answers from the floor. The following is a partial list of subjects to be discussed:

1. Financing small hydroelectric generating stations for heads less than 100 feet
2. Experience with automatic and supervisory control for hydroelectric plants and the range of plant sizes to which they should be applied
3. Extended use of vertical impulse water turbines
4. Use of spherical-type shutoff valves and their advantages over other types
5. Pipe and tubing used for inhibited oil in hydroelectric stations
6. Ball bearings for auxiliary motors
7. Operating large generators at leading power factor loads and stability problems associated therewith
8. Operating experience as to life of hydroelectric generator stator windings with class *B* insulation
9. Experience as to cost and value of protective coatings on internal surfaces of penstocks
10. Auxiliary power requirements in hydroelectric generating stations

CP.** Holcombe Hydro Plant. *H. E. Rhoades*, Northern States Power Company

52-155. Tables of Binomial Probability Distribution to Six Decimal Places. *Joint Subcommittee on Application of Probability Methods to Power System Problems*. Presentation by title only for discussion

2:00 p.m. Switchgear

52-173. A New 14.4-Kv Indoor Compressed-Air Circuit Breaker. *J. E. Schrameck*, Westinghouse Electric Corporation

52-170. Developing a Superspeed Trip-Free Reclosing Circuit Breaker Mechanism. *L. J. Linde, H. L. Peek*, Allis-Chalmers Manufacturing Company

52-231. Pneumatic Operating Mechanisms for Power Circuit Breakers. *R. C. Van Sickle, W. T. Parker, F. E. Florschutz*, Westinghouse Electric Corporation

52-226—ACO.* Temperature Correlation in the Connection of Insulated Wires and Cable to Electric Equipment. *Project Committee on Temperature Correlation*

2:00 p.m. Electrostatic Processes

52-230. A Pulse Method for Supplying High-Voltage Power for Electrostatic Precipitation. *H. J. White*, Research Corporation

CP.** Electrostatic Atomization and Precipitation of Coating Materials. *E. P. Miller*, Ransburg Electro-Coating Corporation

CP.** Monocyclic Constant Current Control for Industrial Precipitators. *H. V. Nelson*, General Electric Company

2:00 p.m. Magnetic Amplifier Test Methods

CP.** Core Matching at High Frequency. *D. H. Toth, L. W. Mader*, Engineering Research Associates

CP.** Production Test Experience on Aircraft Magamps. *K. H. Sucker*, Westinghouse Electric Corporation

CP.** Test Methods for Magnetic Amplifier Cores. *J. R. Conrath*, Vickers Electric Division

CP.** Evaluation of Core Materials for Magnetic Amplifiers. *D. C. Dieterly*, Armco Steel Corporation. There will be a demonstration of test methods

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(*Continued from page 553*)

draulics, and environmental testing. Technical and research laboratories, engineering quarters, the model shop, and the analogue computer room will be seen also.

Electric Machinery Manufacturing Company, Minneapolis (Thursday, June 26, 1:30 to 5:30 p.m. Tickets, 75 cents). Members taking this trip will be shown the manufacture of induction motors, synchronous motors and generators, turbine-generators, allied controls, and magnetic variable-speed drives. These products run to large sizes at this plant which has complete facilities for manufacturing, balancing, and testing them. An exhibit of electromagnetic coupling apparatus and a demonstration of the use of the magnetic amplifier for speed control of the magnetic drive will be seen. En route to the factory, the trip will stop at St. Anthony Falls dam to inspect a new outdoor waterwheel generator installation by this company.

Northwestern Bell Telephone Company, Minneapolis (Thursday, June 26, 2:00 to 4:00 p.m. Restricted to citizens. Tickets free). Various types of local and toll facilities will be observed here. Of interest to telephone engineers will be the recently installed terminal equipment for several major types of toll cable: the *N-1* carrier cable to Duluth, the coaxial cable to Des Moines, and the *K* carrier twin cable to the west. Visitors also will see the television network facilities.

Toll dialing equipment cut-over in February this year will be seen on the tour. This equipment, known as the *A4A* toll crossbar system, connects with 12 other similar installations in the United States to permit direct dialing on long distance calls. The apparatus to be seen cost approximately $4,000,000. It comprises panels of crossbar switches, relay "markers,"

operators' positions equipped with key sets, and a maintenance board panel. There is also a separate, regulated motor-generator and storage-battery power supply for the *A4A* installation.

Brown and Bigelow, St. Paul (Friday, June 27, 9:00 to 12:00 noon. Tickets, 75 cents). This plant prints a major portion of the calendars produced each year. In it much other specialized advertising is printed as well, and it includes one of the half-dozen playing card factories in this country.

Visitors will see scores of machines in operation, printing by offset, photogravure, and by letter press. Many are equipped to handle large production runs and to print several colors.

One of these, a giant Talio-Crome press more than 100 feet long and weighing 100 tons, can print eight colors. It has 53 motors, and a photoelectric cell system that controls register to 1/10,000 of an inch. The press cost $600,000, and when installed with accessories the total outlay ran nearly a million dollars.

In the machine shop visitors will see repairing and rebuilding of printing equipment, and tool and die making for plastic molding and metal stamping operations. Here also the company builds new machines of its own design.

St. Croix Falls Hydroelectric Plant of the Northern States Power Company, St. Croix Falls, Wis. (Friday, June 27, 9:00 a.m. to 4:00 p.m., including luncheon. Tickets, $4.50). This trip will provide a delightful all-day outing along the beautiful St. Croix River. Busses will be routed from Minneapolis via the pioneer lumbering city of Stillwater, Minn., thence across the St. Croix, and along Wisconsin highways to Interstate Park at St. Croix Falls. The group will have lunch at the Interstate Park Pavilion.

A brief visit will be made to the Northern States Power Company's station at the Falls, one of the largest of the early hydroelectric installations. When completed in 1907, it was a principal source of electricity for the Twin Cities, which it supplied over two 50-kv transmission lines; now it has become one component of a large power system, to which it is connected by two 250-kv lines. It has a generating capacity of 21,400 kw.

At Taylors Falls, on the Minnesota side of the St. Croix and directly across it from Interstate Park, some of the largest known "kettle holes" may be explored. These were formed by glacial waters flowing over the basalt cliffs of the St. Croix River gorge in times past. The kettle holes, cliffs, and dells make this an area of unusual interest geologically. The return trip will be made along the Minnesota side of the St. Croix River and through some of the nearby lake country.

Mesabi Iron Range and Duluth, Minn. (Saturday, June 28. Registration for this trip must be made with the committee by Wednesday, June 25. Members may use their own transportation, or the committee will assist them to arrange for some. Those who go can make arrangements to be received on Thursday, June 26, or Friday, June 27, if they wish). In Duluth the Arrowhead Section has arranged for members to be admitted to any of the following establishments: Aerial Lift Bridge, a unique landmark; North-western-Hanna Coal Dock, one of ten installations which handle over 6 million tons annually; Superior Wood Products Company, producers of hardboard from native poplar; Duluth, Missabe and Iron Range Railway iron ore docks, up to 2,200 feet long, which handled 21,000,000 tons last year; M. L. Hibbard Steam-Electric Plant, largest station of the Minnesota Power and Light Company; American Steel and Wire Company, operating two blast furnaces and nine open hearths, blooming and billet mill, merchant mill, and wire mill; Universal Atlas Cement Company, with a complete process producing 1,600,000 barrels a year; Thomson Hydroelectric Station operating under a 364-foot head with 67,350-kw capacity.

Lightning stroke to a full-sized airplane in the laboratory of the Lightning and Transients Institute, Minneapolis, which will be visited during the Summer General Meeting

Duluth is situated at the head of Lake Superior on a natural harbor which is the largest inland harbor in the world. Last year it received and dispatched 11,368 vessels. The annual tonnage of its shipments is exceeded only at New York City.

The Mesabi Iron Range, north of Duluth, is the largest of three iron ranges in the area. The ore is of various grades, from that of low iron content (taconite) to some of the purest and richest in the world. This area is the source of approximately 2/3 of all the iron ore produced in the United States.

The range tour starts at Hibbing, Minn., 8 miles from Duluth. Specific directions and maps will be available for those who wish to drive. The tour can include any of the following mines and plants: Morton Mine, an open pit operation using dragline and conveyor belt; Hull Rust-Mahoning Mine, the largest open pit mine in the world, which has yielded more than 500 million tons of ore; Fraser Underground Mine, where the surface facilities can be inspected; Mountain Iron Taconite Plant, a processing plant now under construction; Missabe Mountain Mine, open pit operation; Rouchleau Ore Processing Plant, for sintering and nodulizing taconite concentrates; Embarrass Mine, open pit mining of ore under a lake; Erie Taconite Pilot Plant, processing low-grade ore into high-grade pellets; Aurora Steam-Electric Station, under construction; Babbitt Taconite Pilot Plant, where ore is mined and processed at one location; Beaver Bay Taconite Development, a large installation under construction with $2^1/_2$ million tons annual output capacity, ultimately expansible to 10 million tons. A scenic drive through Ely, Minn., and along the north shore of Lake Superior through Two Harbors, Minn., can be included in this trip.

EVENING ACTIVITIES

Social events and entertainment have been arranged for every evening except Friday. Monday evening has been set aside for reunions of the various groups at the Nicollet.

The President's Reception in the main ballroom of the Nicollet will start with a smörgåsbord dinner at 6:00 p.m., Tuesday evening, June 24. An evening of entertainment will follow the meal, with Institute officers as guests. Tickets will be available at the meeting at $6.00 each.

A sailboat race on Lake Calhoun will start at 7:00 p.m., Wednesday, June 25. Each AIEE District will be represented by a 20-foot class *D* boat in this contest. The race is to be run over a triangular course. The entire contest may be viewed from the park surrounding the lake, and special busses to the event will leave from the Nicollet. The bus fare is 75 cents.

A demonstration lecture by Professor A. D. Moore of the University of Michigan is tentatively scheduled for 8:30 p.m., Wednesday evening, in the main ballroom of the Nicollet. Various flow patterns will be shown and the operation of the mapper in making a visible flow diagram will be demonstrated to the audience.

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in Minneapolis, Minn., at 10:00 a.m., Monday, June 23, 1952, during the Summer General Meeting.

At this meeting the annual report of the Board of Directors and the reports of the Committee of Tellers on the ballots cast for the election of officers and for the proposed amendments to the AIEE Constitution will be presented. The Lamme Medal will be presented to Arthur E. Silver (AM '07, F '26).

Such other business, if any, as properly may come before the annual meeting may be considered.

Signed H. H. HENLINE
Secretary

Radio Station KSTP in Minneapolis is scheduled for a Summer Meeting inspection trip

The principal event on the entertainment program is the dinner and dance on Thursday evening, June 26. Dinner will be served at 6:30 p.m., followed by dancing from 9 to 12. Dress is optional. Tickets at $6.00 each may be obtained at the ticket desk.

LADIES' PROGRAM

Parlor C of the Nicollet Hotel has been reserved as the Ladies' Parlor throughout the meeting. It will be open Sunday afternoon and Monday morning for establishing and renewing acquaintances among the ladies attending the meeting.

Those ladies who wish to do so may attend the annual meeting Monday morning and the noon luncheon address by Dr. Morrill.

On Monday afternoon at 1:30 the ladies will go by bus to the main campus of the University of Minnesota. An interesting tour of the campus will include the Variety Heart Hospital, the Northrup Auditorium, the radio station *KUOM*, and the Museum of Natural History. The tour will be followed by tea at the Faculty Campus Club in the Coffman Memorial Union. There will be no charge for this trip. Admission is by badge.

Monday evening is reserved for shopping. Minneapolis stores are open that night until 8:45 p.m.

Tuesday a bus trip leaving the hotel at 10:30 a.m. will travel around Minneapolis and some of its lakes, and to the Automobile Country Club on the Minnesota River for luncheon at 1:00 p.m. Opportunity will be afforded for taking pictures on this trip. There will be time for a stroll through the flower and vegetable gardens at the club before returning to the hotel. Tickets at $3.00 include bus fare and luncheon.

Wednesday the ladies will have breakfast in the Garden Room of Donaldson's Department Store at 9:00 a.m. A style show will be presented during the meal. Tickets are $1.00.

At 11:00 a.m. busses will take the ladies from the hotel to Red Wing, Minn. A stop will be made for luncheon at Nybo's, an air-conditioned cafe with an interesting picture gallery. A guided tour of the Red Wing Potteries will follow at 2:00 p.m. This is an opportunity to see the Mississippi River Valley, Lake Pepin, and some unique geological formations. A stop en route at one of the Mississippi River locks is scheduled. Tickets, including luncheon and bus fare, at $3.50 each must be purchased by Tuesday noon.

Thursday, the Betty Crocker Test Kitchens of General Mills will be visited at 9:45 a.m. The ladies will go in small groups from the Ladies' Parlor. Tickets will be available there at no charge.

At 1:30 p.m. the ladies will go to the American-Swedish Institute in Minneapolis for a tour of the building, which houses an impressive collection of Swedish and Swedish-American art, glass, and textiles, besides pioneer and immigrant items and Swedish antiques from the 17th and 18th centuries. Tea will be served at 3:00 p.m., and busses will return to the hotel at 4:00 p.m. and 5:00 p.m. in time for the dinner-dance. Tickets for the trip are $1.00.

REGISTRATION

The registration desk will be open Sunday afternoon, June 22, and daily thereafter from 9:00 a.m. to 5:00 p.m. for the duration of the meeting. Arrangements will be made to expedite registration of those who have sent in advance registration cards. A registration fee of $3.00 will be charged all members and $5.00 for all nonmembers. Enrolled students and the immediate families of members will be registered without payment of any registration fee.

HOTEL RESERVATIONS

Hotel rooms may be reserved by writing directly to the Nicollet Hotel or to the hotel preferred, and stating that the reservation is for the AIEE Summer General Meeting. Rooms with bath are available at the following rates:

Hotel	Single	Double	Twin Beds
Nicollet	$5.00–10.00	$7.50–12.50	$7.50–12.50
Andrews	3.75– 6.00	5.25– 7.50	6.50– 9.00
Dyckman	3.25– 6.00	5.50– 8.50	6.00–11.25
Sheridan	3.25– 3.50	4.50– 6.00	7.00– 8.00
Curtis	3.50– 5.00	4.50– 6.00	6.50– 7.50
Leamington	4.50– 5.50	6.00– 7.50	7.50– 9.50

Information relative to motels and maps for those who plan to drive may be obtained from the Tourist Information Bureau, Minneapolis Chamber of Commerce, 1750 Hennepin Avenue, Minneapolis 3, Minn. Specific resort information will be available at meeting headquarters.

GENERAL COMMITTEE

The members of the 1952 Summer General Meeting Committee are: R. R. Herrmann, *General Chairman;* H. E. Hartig, *Vice-Chairman;* H. P. Brunoke, *Secretary;* A. J. Hendry, *Treasurer;* J. R. North, *Vice-President, District 5;* D. D. Ewing, *Director;* G. B. Germain, *Chairman, Minnesota Section;* R. N. Faiman, *Chairman, Red River Valley Division;* R. B. Wiprud, *Chairman, Arrowhead Section;* E. H. Hagensick, *Entertainment;* H. W. Meyer, *Fiftieth Anniversary;* R. H. Olson, *Finance and Budget;* W. H. Gille, *General Sessions;* L. A. Rietow, *Hotel Reservations;* M. I. Risley, *House and Equipment;* P. G. Bowman, *Inspection Trips;* E. A. Wold, *Printing;* R. M. Kalb, *Publicity;* E. B. Doescher, *Registration;* R. G. Lynn, *Sports and Prize Meets;* J. H. Kuhlmann, *Students' Activities;* P. A. Cartwright, *Technical Program;* H. E. McWethy, *Transportation;* Mrs. H. E. Hartig, *Ladies' Activities.*

Development and Use of Electric Energy South West District Meeting Theme

The hospitality of the AIEE South West District was extended to the Institute on the occasion of the meeting held at the Jefferson Hotel in St. Louis, Mo., April 15–17, 1952, where approximately 600 members enjoyed an excellent technical and social program.

The general session was held on the morning of April 15 with H. R. Fritz, District Vice-President, presiding. After welcoming the visitors, Mr. Fritz introduced AIEE President F. O. McMillan, whose address, "Our Heritage From Engineering Education," traced the history of the ascent of the teaching of engineers in 18th century France, England, and Germany, and the early schools in the United States to the vast universities of the present. (For complete text, see pages 487–91.)

Ralph E. Moody introduced J. B. Thomas, President and General Manager, Texas Electric Service Company of Fort Worth, who spoke on "Research, Development, and Utilization of Electric Power." He first brought out that older members of the engineering profession had an obligation to hand on their experience to the younger men and women. Although there were marvelous engineering feats accomplished many centuries ago, opportunities to explore the engineering situation came only about 200 years ago. The whole art of electrical engineering grew in men's minds—they had nothing on which to build and there is no limit to which it can expand; it rests wholly on men's imaginations and abilities.

Our strength in the United States is our

ability to out-produce other nations and this strength is dependent upon electricity. The philosophy of the electrical science's leaders, men like Edison, Steinmetz, Lamme, and others, is worth following because theirs was the knowledge combined with engineering honesty. Because this philosophy has become a part of the engineer's technical thinking, he should take his place among leaders in governmental affairs.

Research groups are not only necessary to engineering progress, but also to the progress of civilization. There should be a simplification of modern gadgetry to avoid public resentment, but men are slow to learn. For how long were pointed sticks used instead of forks? Men climbed through a hole in shirts for many years before someone had the idea of "coat" shirts. More and more thought should be given to the development of electric energy so that greater efficiency can be obtained.

Thought should be given to the freedoms under which all electrical developments have been made and the engineer should take his rightful place in maintaining those freedoms.

GET-TOGETHER LUNCHEON

After the close of the general session, members gathered for the get-together luncheon. R. Slinger, Chairman of the St. Louis Section, introduced L. W. McLeod, Vice-President, South West District; Westinghouse Electric Corporation, who presented an illustrated talk on "The Land of Rich Rewards." He told how the southwestern states have developed their natural resources and the part that electrical engineering has played in this great expansion. The rapid development of industry in that area has been paralleled by the electrical utilities.

ENTERTAINMENT

The stag smoker was held in the Gold Room of the Jefferson Hotel on Tuesday evening. After a roast beef dinner, an excellent variety show was provided for the members' enjoyment.

The next evening the informal dinner-dance was held after a predinner gathering period in the Crystal Room. The entertainment and music for dancing were thoroughly enjoyed by the large number of members and guests.

Three-Day Technical Program Presented at Recent South West District Meeting

Industrial Power Utilization. Four District papers were presented in a session on industrial power utilization with W. J. Roa presiding. The first paper gave a résumé of "Development of the Anheuser-Busch Electric System" from the time of the initial installation, which consisted of four 500-kw motor-generator sets, to the present 13,800-volt system and the installation of a second 9,375-kva generator last year. Plant interrupting requirements and momentary requirements were reviewed. As the system load increased, economy dictated the reason for going to 13,800 volts rather than 4,100 volts.

The second paper, "Industrial Power Utilization From the Utility Standpoint," by P. W. McCormick of the Union Electric Company of Missouri, brought out the important functions which the power sales engineer performs in connection with several different types of industrial loads that bring about customer good will and satisfaction.

"Five Years of Operation and Experience With Heat Pumps in St. Louis" was described by G. S. Whitlow of the Union Electric Company of Missouri, who had an installation in his residence. The first installation was made in the fall of 1946 and placed in service December 1. It was custom-made with brine on both sides of the system and difficulties were experienced with leaks, pump failures, and so forth. The second heat pump was assembled December 1, 1947, and the brine circuit through the house was eliminated. A 1,600-foot ground coil was installed in trenches 4 feet deep and thermocouples placed at various depths furnished valuable information on ground coil installations. A depth of greater than 4 feet cannot be justified. A third installation had a coefficient of performance of 1.83 in a 65,000-Btu house. After 14,000 hours of continuous operation, no difficulties were encountered and frozen earth gives good results as ice is three to five times a better conductor than the unfrozen earth. A 900-foot ground coil on a 30- by 50-foot lot supplies heat with two 3-ton compressors.

It was brought out that the operation of an auxiliary air coil in summer is entirely satisfactory, but air circulation is essential and the cost of an air coil is little if any different from that of a ground coil. The author concluded that much is yet to be learned about heat pump installations. The load factor is comparatively good and new techniques and designs will result in greater savings. Much improvement is expected in compressors and the control for the ground coil is simple and reliable. In discussion, it was brought out that panel heating does not lend itself to cooling in the summer due to sweating, and circulation of air is necessary. An average residence with a 2,000-kilowatt-hour load per year with a heat pump installed would have a load increase of 15,000 kilowatt-hours per year.

In the fourth paper, "Development of the Aluminum Ore Electric System," M. B. Keen traced the growth of the electric system with the increases in plant capacity and the factors that will determine the type of electric system for this kind of plant were discussed. A loop transmission system of 15 kv has 1,500,000-centimeter conductors of pure aluminum as caustic soda is used in process and corrosive vapors are in the atmosphere. Examination of the aluminum cables after a long period of service indicated that the dye marks could still be seen so there was no deterioration.

Aircraft Electric Equipment. The first of two sessions on the electric equipment employed in aircraft was held Tuesday afternoon April 15 and presided over by J. C. Lebens, Jr., Bussman Manufacturing Company. There were four technical papers, three presented by title only, and two District papers.

The first technical paper was "A New Circuit Breaker for Aircraft Electric Systems, 120 Volts A-C or D-C," by B. S. Beal III and P. J. Reifschneider, General Electric Company, and read by the latter. Although protective equipment for low-capacity circuits in 28-volt d-c systems has been available, there has been a lack of equipment for similar and higher capacity circuits in 125-volt systems, both alternating and direct current. The authors described a new type of circuit breaker with ratings up to 125 amperes, 115 volts alternating or direct current, which will operate up to 50,000 feet within an ambient temperature range from −55 degrees to 71 degrees centigrade; its ultimate trip current is 138 per cent of its rated current at 25 degrees centigrade and its continuous current capacity is 115 per cent of its rated current at the same temperature; its 200-per-cent current calibration is 10–100 seconds at 25 degrees centigrade. A temperature-compensated thermal element maintains the calibration of this circuit breaker within relatively narrow limits over a wide range of ambient temperatures and with minor changes this circuit breaker can be arranged for manual operation and for application in 28-volt systems.

In the discussion which followed the presentation of this paper, the chairman spoke of an aircraft fuse which is now under development and its uses. Mr. Larson of the Naval Research Laboratory, stated that from an application viewpoint he was against putting such a device in the generator feeder as it might compromise the entire electric system at a time when it is most needed; that there should be no current-limiting device whatsoever in generator feeder. He urged that manufacturers guarantee that a circuit breaker, such as the one described, will function.

J. K. Howell, Westinghouse Electric Corporation, and Captain P. E. Burket, United States Air Force, presented a District paper, "Preventive Maintenance Aids Large Aircraft A-C System Progress," which was read by the former. The *B-36* bomber is the first large aircraft to use an a-c power system successfully. This equipment consists of four 30-kw alternators operating at 6,000 rpm with an output of 3-phase 208/120-volt 400-cycle alternating current. The prime mover for each alternator is an engine-driven hydraulic torque-converter designated as a constant-speed drive.

After the preventive maintenance program got under way in 1950, it was found that most failures in the power generating system resulted from: (1) minor design deficiencies; (2) physical failure of wiring; and (3) erroneous connections in the various circuits. The inspection system for the alternators was arranged to coincide with the periodic aircraft inspections. Since its inception, this inspection has reduced the amount of flight-line maintenance on the alternator by showing up conditions which would result eventually in the unit's failure. The more common unsatisfactory conditions found during these routine checks were: oil and grease on the commutator, slip rings, and brushes, and burned or pitted commutator bars due to short brushes.

One of the most serious problems was the partial or complete disintegration of an alternator during operation. A large percentage of the failures was found to be due to the overspeeding of the unit up to 18,000 rpm in

Enjoying a friendly discussion during the recent South West District Meeting are (above, left to right): W. J. Steiling, Anheuser-Busch Inc.; P. W. McCormick and G. S. Whitlow, Union Electric Company; W. J. Roa, Sverdrup and Parcel, Consulting Engineers. At left, AIEE Directors E. B. Robertson (E. B. Robertson, Inc.) and R. F. Danner (Oklahoma Gas and Electric Company) greet Lieutenant Colonel R. E. Thornton on leave with the Corps of Engineers

some cases. This came about as a result of the failure of the governor solenoid valve, the governor junction box, or the tachometer generator; or the wiring associated with any of these. Efforts are presently being made to develop a more positive protective device for the system.

The second District paper, "Electronics Equipment Installation in Fighter Aircraft," was presented by A. R. Andersen, McDonnell Aircraft Corporation. There has been a tendency on the part of the Air Force electronics experts to increase the amount of their equipment in the modern fighter aircraft without too much thought being given to the space available, power requirements, cooling facilities, and so forth. Furthermore, an unavoidable lapse of 2 years or more is common between the drawing-board stage of the airplane itself and the time when the first model is ready to fly. It is in this design and building period that some new ideas are hatched resulting in changed specifications in some electronic equipment which necessitate changes in the airframe.

This continual changing adds greatly to the cost of the aircraft as well as an increase in the building time. In the interest of all-around efficiency it is highly desirable to have a more co-ordinated design program so that some of these losses can be eliminated.

Three technical papers were presented by title only for discussion. These were:

"Distribution System Reliability of 28-Volt D-C Aircraft Electric Systems" by K. W. Carlson and E. S. Sherrard, General Electric Company.

"Weight Analysis of Aircraft Actuators" by H. M. Geyer and R. C. Treseder, General Motors Corporation.

"Reduced-Voltage D-C Motor Controllers for Aircraft" by H. J. Finison and W. C. Andersen, Armour Research Foundation.

Science and Electronics. Two technical papers and two District papers were presented at the Wednesday morning session dealing with advances in the electronic arts over which J. W. Rittenhouse, University of Missouri, presided. The session was opened by Robert Kahal, Washington University, who presented the paper, "Synthesis of the Transfer Function of 2-Terminal Pair Networks." The open-circuit transfer function of the 2-terminal pair network is of interest theoretically as well as in certain applications. It is important to establish the form and properties which a physically realizable transfer function, as a function of frequency, may assume. This was done by the author for certain classes of networks with suitable restrictions. The networks considered were assumed to be passive, and constructed with a finite number of lumped, linear, and positive elements, R, L, and C.

"Recent Developments in Transistors" was the title of the District paper presented by J. A. Morton, Bell Telephone Laboratories. Four years ago transistors had not been produced which were similar electrically, reliable, and which could perform at anywhere near the way they can today. Although mass production is yet to come, the transistor has opened up a new field in electronics.

After describing the functioning of the basic and the junction transistors, the author described the performance, range, and reproducibility of the latest transistors, comparing these with those of 1949. As far as reliability is concerned, the life has been increased from 10,000 to 70,000 hours; the temperature coefficient has been reduced from 1 per cent per degree to 0.25 per cent; and while no data were taken of the shock and vibration characteristics 4 years ago, today the shock figure stands at more than 20,000 g's and that for the vibration from 20 to 5,000 cycles per second is negligible to 100 g's.

Regarding the increased performance of the latest transistors compared with those of 1949, the following data were given: current gain, increased from 5 up to 50 times; single-stage gain, from 18 decibels to 45; noise figure reduced from 50 decibels down to 10; the frequency response increased from 7 to 50 megacycles; the power output increased from 0.5 watt to 2 watts; the feedback resistance from 250 to 70 ohms; and the photoelectric ratio (light to dark) changed from 2:1 to 20:1.

The second technical paper of the session was presented by S. H. Van Wambeck, Knapp-Monarch Company, and W. A. Stein, United States Naval Postgraduate School; its title was "A Special Dynamometer for Testing Small Motors," and it was read by Mr. Stein. In the testing of small motors the eddy-current brake is ineffective; prony brakes and other similar common types are impractical to use in the very small sizes. The design of the dynamometer described by the author is based upon the principle that output torque is equal and opposite to the reaction upon the motor frame, regardless of the source of external loading on the shaft. The motor under test is mounted in a pivotal cradle arranged to permit the measurement of the reaction torque. One model was built using a 20-inch scale beam and movable weights. A pointer was used to identify the balance position and this arrangement was found to be advantageous in that the effect of leads, off-center pivoting, and so forth, were minimized and the range of torques which could be measured was from 2 inch-ounces up to 150 inch-ounces. The second model constructed used a pendulum for the direct measurement of torque. Here there was a nonuniform scale, with unit distance representing smallest increments of torque around the zero point, due to the fact that the pendulum torque varies as the sine of the deviation angle.

On both models the leads were flexible and were suspended essentially along the rotational axis of the cradle. The pivoted cradle was originally mounted on a knife-

edge but difficulty was experienced and it was changed to ball bearings. The loading device is a variable-speed drive which fixes the speed of rotation at the value for which a torque reading is desired. In both variations of the dynamometer a 1/3-horsepower motor was used to drive a variable-speed hydraulic transmission. The hydraulic units are reversible and operate at any speed up to 1,800 rpm. A selection of pulleys and belts makes possible the choice of any operating speed up to 12,000 rpm at the auxiliary shaft which couples to the motor under test.

The final paper of the session was a District paper, "Magnetic Amplifier Applications," by V. H. Krummenacher, Vickers Electric Division, Vickers, Inc. After discussing the several advantages of the magnetic amplifier and some of its applications, the author considered the following five applications, which he explained in detail: a frequency- and voltage-regulated motor-generator set incorporating a magnetic particle clutch as the frequency-adjusting means; an automatic main field-voltage regulator for large 150/180-cycle-per-second welding generators; an automatic main field-voltage regulator for under-car diesel-engine-driven railway power plants; a servo amplifier; and a regulated static d-c power supply.

Transmission and Distribution I. Several problems were dealt with in a series of four papers presented in a session on transmission and distribution with O. S. Hockaday presiding. The first paper, entitled "Application and Operation of Switched Capacitors for System-wide Requirements" by B. M. Gallaher of the Texas Electric Service Company, presented a comprehensive treatment of the problems, solutions, and concepts encountered in extensive capacitor applications. In discussion of the subject, H. E. McDowell of Ebasco Services Inc., considered the paper excellent coverage of a currently important subject. He believed the author's program governing the installation of capacitors contemplated a cautious approach. Switching during a period of reduced loads which results in high power factors was discussed. In respect to protection against explosion, Mr. McDowell suggested an "explosion fuse" in capacitor cases synonymous to the fuse plug that once had wide use in relatively low-pressure steam boilers.

The second paper presented dealt with expanding the capacitor frontier and was presented by V. A. Rydbeck of the General Electric Company. He gave as four factors which contribute to this expanding frontier: 1. increased loading; 2. increased use of appliances, fluorescent lights, and motorized devices; 3. increased distances and transformation between the generating source and the load area; and 4. a changing ratio between capacitor and cleetric equipment costs. Valuable curve data were presented.

Another paper dealt with the subject of "Load Pickup After Extended Outage" and it was presented by A. W. Edwards of the Westinghouse Electric Corporation. He described additions made to a standard sectionalizer to allow it to break the system into segments automatically and then progressively re-energize the segments to lower the peak demand on the system during load pickup. The load pickup switch would eliminate most of the time-consuming operations generally associated with recovering loads after extended outages and it would give the same fault protection as a sectionalizer. In discussion, an alternative approach by increasing relay settings was given by G. E. Brooks of the Oklahoma Gas and Electric Company. Feeders on their system are protected by extremely inverse induction relays set up to 240 per cent of feeder capacity. With branches protected by fuses at the feeder center, a co-ordinated protection scheme with ability to carry the expected temporary overloads following extreme outages is provided. To prevent blowing feeder center and branch fuses on transient faults, a fault selective scheme of co-ordination which consists of a set of instantaneous overcurrent relays controlled by a special electronic time control relay is employed. Another discussion by Ray Robson of the Union Electric Company of Missouri reported that the problem of restoration of service after outages had not yet reached serious magnitude on their system. In areas of heavy industrial loads, the problem is offset by the motor loads which are released automatically and require manual restarting. O. Ramsaur of the Pennsylvania Power and Light Company also discussed the paper and commended the authors for bringing out a device to help solve the problem, but he felt that a more complete description of how the sectionalizer operates was necessary before its merits and demerits could be judged properly. In the rebuttal, Mr. Edwards explained that the device was not applicable to sectionalizers built by other manufacturers or to the Westinghouse sectionalizers, but that it was a completely integrated design of its own. The system does not operate as an under-voltage device but as an overcurrent device.

The fourth paper, "Complex Multiplication of General Circuit Constants," by R. D. Goodrich, Jr., of the Bureau of Reclamation, presented a short-cut method of complex multiplication employing a 10-place desk calculator. The computation of system power flows and composite constants were greatly facilitated resulting in considerable labor-saving and the author demonstrated the operation of the desk calculator.

Electric Machinery II. In this session with P. G. Wallace presiding, a variety of problems were presented. The first paper by W. L. Ringland of the Allis-Chalmers Manufacturing Company analyzed the several factors which contribute to magnetic noise in salient-pole synchronous machines with a view toward predetermining the probable magnetic noise for a particular machine design.

In the second paper, B. G. Hatch of the General Electric Company reviewed the three cycles for the gas turbine already installed in central station service. He pointed out the many possible applications of the gas turbine with present ratings of 3,500 kw and 5,000 kw such as in base load plants, peak load plants, standby service, end-of-line plants, and to improve station heat rate or heat balance. The gas turbine which can be started up quickly serves well in regions where water is scarce or costly and its ability to generate steam at low cost with a waste heat boiler makes its installation for industrial power generation appear particularly attractive. The author was complimented by R. F. Danner of the Oklahoma Gas and Electric Company on a clear, concise presentation. With some 3 years' experience, Mr. Danner reviewed the reasons for the installation of a gas turbine, how it operates, and views of the future. The initial installation was made because the gas turbine afforded an opportunity to increase the plant capacity just after the war with a minimum of critical materials. In some 19,350 hours of actual operating service, the machine has been forced out of service for only 34 hours and is so well thought of that the company is presently installing a second unit, expected to be in service about June 15. In relation to the favorable view of the Union Pacific about the gas-turbine locomotive, C. H. Griffin of the Missouri-Kansas-Texas Lines raised the question as to whether the comparison was made between diesel passenger locomotives or freight locomotives.

The third paper was presented by H. F. Ostman of the Union Electric Company of Missouri and a comparison was drawn between the conventional types of transformers and the protected types. No

Photographed during the South West District Meeting in St. Louis are, left to right: J. B. Thomas, Texas Electric Service Company; R. E. Moody, Union Electric Company; F. O. McMillan, President AIEE; and H. H. Henline, Secretary AIEE

failures of protected transformers were encountered due to lightning, overload, or short circuits. Costs in the territory of the Union Electric Company of Missouri compared favorably with the national average costs reported in the recent Westinghouse survey which is probably the most extensive survey of its kind ever undertaken. In discussion, H. A. Nicholson of the Kansas City Power and Light Company complimented the authors and drew attention to the fact that age is an important factor in the failure of transformers. However, Mr. Sumner pointed out that many of the protected types have had up to 15 years of service and that the impulse strength of old transformers of the oil-filled type is nearly as high as that for the new types.

The last paper in the session dealt with the distribution type of regulator which was made available about 2 years ago and W. L. Peterson of the Allis-Chalmers Manufacturing Company reviewed the important factors that influence the distribution engineers' choice of method of regulation in the light of present-day developments.

Power System Protection. A standard plan for system protection was given in a paper on "High-Speed Relaying" by L. F. Kennedy of the General Electric Company which was presented by C. R. Mason. As the load of most systems will double in the next 10 years, a philosophy was presented which urges power companies to standardize on high-speed relay equipment which would require the least application effort and reliable relays are available which have been tested for several years. While this type of protection is the most expensive, it was believed to be the cheapest in the long run and practical because of the advanced state of relay art. In discussion, A. J. Nicholson inquired as to what could be expected in the case of self-clearing transient faults where tripping is undesired and W. J. McKune of the University of Texas referred to the transistor and electronic relays. However, Mr. Mason explained that some inertia of the mechanical parts of a relay was desirable and that one should proceed slowly with the electronic superspeeds as tripping was undesirable on the transient faults. Another paper dealt extensively with the subject of "Surge Protection of Dry Insulated Equipment" by R. C. Dickinson, G. L. Moses, R. L. Schwab, and Edward Beck of the Westinghouse Electric Corporation. Mr. Beck introduced the subject and spoke mainly from the point of view of proper application of the lightning arresters. Mr. Schwab covered the dry transformers and switchgear and Mr. Moses, the rotating machinery.

In the third paper, "The Influence of Power System Design on Protective Relaying" was shown by J. L. Blackburn, Westinghouse Electric Corporation, who illustrated the types of protection for several different kinds of station busses as well as the case of multiterminal transmission lines.

The last paper, entitled "Plains Lightning of the Middle West," was presented by D. D. Clarke of the Kansas City Power and Light Company. This paper showed that an unusually severe stroke broke a shield wire at mid-span and analyses of the destructive results by several methods of approach showed current magnitudes in the stroke of about 500,000 to 1,000,000 amperes.

System Operation. Four District papers were presented at the Thursday morning session devoted to system operation over which E. E. George, Ebasco Services, Inc., presided. The first paper was presented by Arnold Rich, consulting engineer, in which he summarized a classification of outages of facilities in electric-power systems. He presented the following list for review and comment: An outage is an event, necessitated by adverse conditions involved in the operation of power-supply facilities, that curtails the system capacity available for service; under this general heading, he broke it down into total outages and partial outages. Scheduled outages are those that can be previously arranged to reduce, as much as possible, any consequent reductions in the total system power supply needed, from time to time; under this heading were included maintenance, overhaul, and construction outages. Next were unscheduled outages that occur at once or must be made in a very short time, due to the development of unforeseen and critical system-operating conditions, so that they cannot be effectively co-ordinated in the system maintenance plans; under this came forced and emergency outages. Special outages were defined as those which require some special consideration before their complete classification can be definitely determined. These are subdivided into the following: combined or split outages; secondary or indirect outages; consecutive or repeated outages; and extended long-time outages.

Among the several discussions on this paper was one submitted by C. W. Minard, Omaha Public Power District, who, as chairman of the Reserve Capacity Committee of the Southwest Regional Group of the Interconnected Electric Power Systems, stated that his committee had had to establish classifications of outages, which had been grouped into three sections: forced outages, maintenance scheduled outages, and emergency scheduled outages. He suggested the following general classifications for outages of generating facilities: 1. catastrophes, for which reserve capacity would not be provided; 2. outages which affect reserve capacity requirements; and 3. outages which should have no effect on reserve capacity requirements.

"From Wire to Microwave on the Union Electric System" by P. T. Ramey and C. W. Blood, Union Electric Company of Missouri, was presented by the latter. The first privately owned communication network was constructed about 1913, connecting the hydroelectric plant at Keokuk, Iowa, with the Union Electric substation in St. Louis, Mo., a distance of approximately 200 miles. Although its original purpose was for expediting patrolling and maintenance of the 110-kv transmission lines, as substations were built along the lines, it was also used for dispatching. In 1924 experimentation in power-line carrier was begun on a 13.8-kv line between St. Louis and St. Charles, Mo. All the parts were handmade and the coupling capacitors were built from old bushings. As experiments were successful, the following year a carrier-current system was installed on a 30-mile transmission line from the Cahokia Plant to Crystal City, Mo., where there was a large load center. In 1930 a new carrier-current system was installed with the hub of the network in St. Louis. This was an automatic simplex system operating on 62.5 kc and was a 4-party line. In 1940 a second carrier-current duplex system was installed using side-band transmission and erected upon the existing copper telephone line. Five years later a short-wave radio system was put into operation in the St. Louis area, establishing communication with the company's mobile units operating throughout the city. In 1947 a telemetering system was introduced, which has to be revised in the near future to care for the expanding demands.

"Modern Railroad Communications and Signaling" was presented by R. M. Laurenson, St. Louis and San Francisco Railroad. For operation of the 5,000 miles of track in nine states, this railroad has 2,500 miles of dispatchers' telephone facilities, the same amount of secondary telephone wire, 4,000 miles of printed telegraph, and 6,000 miles of carrier telephone circuits. The signaling circuits operate through the tracks, which provide a 3-position automatic signaling system for locomotive engineers and control the red, green, and yellow signal lights along the right of way. The centralized traffic control provides dispatchers with a complete picture of trains' locations automatically.

The final paper of the session was presented by L. E. Verbarg, Missouri-Pacific Railroad, its title being "Contemporary Train Radio Equipment Design." In order to have interference-free communication between mobile units and between mobile units and wayside stations, the maximum dependable range should be approximately 8 miles between the mobile stations and 15 to 20 miles between mobile and land stations. To provide radio channels for such communications, the Federal Communications Commission authorized a band of 39 channels between 158 and 162 megacycles primarily for railroads. With 23 railroads operating into Chicago, 18 into St. Louis, and 16 into Kansas City, and assuming that each railroad requires at least 3 channels, it is evident that there are insufficient clear channels available.

The requirement of interference-free communication under present railroad operating conditions is one of the newest and most difficult to meet. In large railroad terminals, it is common for engines of one road to enter switching yards of other roads while making freight-car interchanges. The delivering engine may be only a few yards distant from those of the receiving road and to the base station there may be only a distance of only a few hundred feet. It is with such problems that the designers of railroad radio equipment have to deal and to date all these complications have not been overcome; however, progress is being made and radio has assisted and eased the operation problems inherent in every railroad by facilitating communications to a great extent.

Communications. Three District papers and one technical paper were presented at the Thursday afternoon session devoted to communications over which W. B. Stephenson, Southwestern Bell Telephone Company, presided.

The first District paper, "Exploitation of Message Statistics" by B. M. Oliver and R. E. Graham, Bell Telephone Laboratories, was presented by the latter. Speech can

be changed into a modulated signal, which is the equivalent of coding. In a 10-cycle band, 20 signals per second can be sent and this can be sampled, which does not have to be too accurate.

It was shown in the case of pulse code modulation how sample amplitudes, 0 to 8, could represent a binary code and the appearance of the resulting pulse group. The wider the bandwidth, the greater the number of pulses can be sent.

The author showed how much easier it was to read a sentence written in capital letters with the lower halves of the letters cut off than it was to read a sentence with the top halves of the letters missing. This illustrates a correlation and an association, just as there is among parts of a picture. In radio transmission, the transmitter dictates the on or off pulses, that is one bit of choice, and the receiver has to ask what is missing. Fewer bits need be sent if there is correlation. Six bits are required for a standard code group. In television signals, about three bits per sample are needed with linear prediction. Here, the transmitter subtracts the prediction at one end and it is added at the receiving end.

By means of the frequency of recurrence of letters in the English language and the recurrence frequency of letters after EN and TH, the author illustrated peaked distributions. He developed the way coding could be applied to television signals.

"New Instrumentalities for the Short-Haul Toll Telephone Plant" was given by H. R. Huntley, American Telephone and Telegraph Company. Approximately 20,000 different places—cities, towns, and villages—in the United States and Canada are connected by telephone facilities to one another and have access to practically all telephone systems throughout the world. The author considered the job of connecting these 20,000 places into the backbone network and connecting near-by places to one another, that is, the short-haul field.

After summarizing the desirable characteristics for facilities in the short-haul field, the *N1* carrier and the *O1* carrier systems were described. The former is a cable system and provides 12 circuits on two cable pairs (1 quad) in a single cable. The *O1* carrier system is really not a single system; actually it will consist of four separate systems each providing up to four telephone circuits. Any one or all four systems can be put on a single open-wire pair. A new type of repeater, the *E1*, has become available which provides gain by providing negative resistance, negative inductive reactance, and positive capacitive reactance, as desired. The first of these can be obtained only by supplying power; the repeater thus must have amplifiers arranged so that resistance, capacitance, and inductance in an adjustable network are reversed in sign when presented to the line.

The technical paper, "Design of Low-Frequency Constant Time Delay Lines," was presented by C. M. Wallis, University of Missouri. In low-frequency applications delay lines consist of a cascade connection of L-C network sections using lumped constants. Ideally, the line should have no attenuation; its characteristic impedance should be constant, and the phase shift should be a linear function of frequency. With the latter condition, the time delay is constant and the character of the signal is unchanged as it goes over the line.

When the frequency range lies between zero and some arbitrary upper limit, an L-C network of the low-loss type is used. There are several whose characteristics make them useful in delay-line design; these are the M-derived, the bridged-T, the capacitance-shunted, and the Unsymmetrical Pierce sections. The author showed that the last-mentioned section offers distinct advantages as only two components per section are needed and the section constants are of easily procured sizes.

The final paper of the session, "The Responses of Certain Basic Circuits to a Triangular Pulse," was by K. G. Black and T. J. Higgins, University of Wisconsin. To fill the need for the development of a circuit theory that deals with waves of a discontinuous character, a catalogue of transient response to some fundamental and basic circuits of a triangular pulse has been achieved by the authors. The set of basic signals comprise the step function, impulse function, and rectangular, triangular, trapezoidal, exponential, and sinusoidal-loop pulses. A tabulation of the charge, current, and derivative of current responses of basic circuits to step function, impulse function, and rectangular pulse signals has been already made, but not for triangular pulses. As the response of a linear system to a triangular signal underlies solution of many problems in various physical domains, the authors have calculated and tabulated a table of responses of basic circuits to an isosceles triangular pulse.

Engineering Education. Before a well-attended session of industrial and educational people, two important papers were presented which indicate the changing trends in engineering education in the light of the present manpower shortage. Dean A. S. Langsdorf presided and the papers were as follows:

"Tomorrow's Engineer—in Preparation," K. B. McEachron, Jr., General Electric Company

"Tomorrow's Engineer—in Use," Guy Kleis, Westinghouse Electric Corporation

In the first paper, K. B. McEachron, Jr., analyzed the situation, pointing out that there have been substantial shifts in the way in which we have lived in the last two decades which have brought about a decline in the curiosity of children for things scientific and a decline in the ability to create or tinker. Parents were asked to play more with their children and to stimulate their creative ability. The paper also reported that successful meetings at the high school level had been held in which engineers took part and answered questions which brought out the application of scientific principles and the value of mathematics and algebra. Several ways in which the Sections or members in the Sections could help to enhance interest in the sciences and engineering were suggested. In the latter part of the paper, Mr. McEachron referred to current experiments in engineering education and ways of strengthening and improving the effectiveness of engineering education were suggested so that the reduction in numbers of engineering graduates would be more than offset by the superior abilities of the graduates in the future.

In the paper on "Tomorrow's Engineer—in Use," Mr. Kleis brought out steps which already are being taken by industries to

Lamme Medal Nominations for 1952 Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal, to be awarded early in 1953, may be submitted by any member in accordance with section 1 of article VI of the bylaws of the Lamme Medal Committee, as follows:

"The committee shall cause to be published in one or more issues of *Electrical Engineering*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the Secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

Article V, section 2, specifies that: "The committee in making the award shall carefully observe the limitation imposed by Mr. Lamme, that the recipient must have 'shown meritorious achievement in the development of electric apparatus and machinery.' This shall be taken to mean that the meritorious achievement must be of such character that it has resulted or will result in the production of substantially improved electric apparatus or machinery. Any work which meets this requirement is admissible whether it be (*a*) in development of the theory involved; (*b*) in development of the characteristics of the materials employed; (*c*) in development of over-all design; or (*d*) in development in other ways which results in substantial improvement in electric apparatus or machinery. The words 'electric apparatus or machinery' shall be taken to indicate discrete and self-contained devices which may or may not include mechanical moving parts without limitation as to the field of application. They shall not be taken to include transmission or distribution systems as a whole, but rather to include the apparatus and machinery that is used in making up such systems."

bring about better utilization of engineers, the many advantages of industrial training programs for engineering graduates, and the programs for continued education. In conclusion, he predicted that the experienced engineer can expect that a higher percentage of his total work will fall in more clearly defined bands at a higher professional level and that the new engineering graduates who enter industry will have the benefits of a well-planned training program and placement in jobs that best suit their abilities and interests as well as the advantages of a continued educational program in the community. Both papers will be published in full in the July issue of *Electrical Engineering*.

Student Branches Convene During Recent South West District Meeting

Student activities during the South West District Meeting began with registration at the Hotel Jefferson or at Graham Chapel on the campus of Washington University on Thursday morning, April 17. During both morning and afternoon, tours were taken to the cyclotron at the university as well as several places of interest about the campus and an inspection trip was made to the Meramec Power Plant. Sessions were held all day Friday and Saturday morning at which 15 papers were presented by the students in competition for the AIEE South West District Meeting Branch Paper Prizes and the prizes offered by the St. Louis Section. Awards were made at the banquet held Saturday noon in the Hotel Kingsway. Friday noon there was a luncheon of incoming Branch chairmen at the Student Center and a luncheon meeting of Student Branch counselors was held in McMillan Hall.

BRANCH COUNSELORS' LUNCHEON

The Student Branch Counselors' luncheon and meeting was conducted by Professor P. M. Honnell, Chairman of the District Committee on Student Activities. Professor David L. Johnson of the Oklahoma Agricultural and Mechanical College was elected chairman of the District Committee on Student Activities for the coming year, and he will serve as the District Counselor Delegate to attend the Summer General Meeting in Minneapolis. In accordance with established procedure, the next Student Branch Convention will be held at the Oklahoma Agricultural and Mechanical College in Stillwater. Student dues, $25 for Branch operation, address records of graduate seniors, Section and Branch co-operation, and a manual for Branch operation were among the other matters discussed. It was voted that Professor Bruce Wiley of the University of Oklahoma should proceed with the preparation of the manual.

PROGRAM

Friday, April 18

9:00 a.m. Opening of Convention (Graham Chapel)

Dean L. E. Stout, Dean of the School of Engineering of Washington University and Director of the Sever Institute of Technology

Dr. R. J. W. Koopman, Chairman of the Department of Electrical Engineering of Washington University and Chairman of the St. Louis Section Committee on Student Activities

Dr. P. M. Honnell, Professor of Electrical Engineering at Washington University, Student Counselor to Washington University Branch AIEE, Chairman of the South West District Committee on Student Activities.

9:45 a.m. Technical Paper Session I

H. L. Funk, Chairman, Washington University Branch, presiding

Corrosion Prevention by Electrical Means. *M. K. Enns*, Kansas State College

A Punched-Tape Memory and Response Device. *D. M. House*, University of Kansas

Automatic Speed Control of Wound-Rotor Induction Motors Using a Liquid Rheostat. *J. W. Smith*, Louisiana Polytechnic Institute

A New Method of Speed Control for a Single-Phase Induction Motor. *D. W. Putman*, University of Missouri

Multiple-Trace Oscilloscope for Observation of Transients. *C. M. McDowell*, Missouri School of Mines and Metallurgy

1:30 p.m. Technical Paper Session II

Merle E. Parmer, Chairman, University of Missouri Branch, presiding

An Electrical Method of Soil Moisture Determination. *R. E. Thomas*, New Mexico College of Agriculture and Mechanic Arts

Characteristics of the Radion Tube, Preliminary Report. *A. R. Engquist. R. S. Christy*, University of New Mexico

Engineering—A Profession, Not a Trade. *Gene Brewer*, Oklahoma Agricultural and Mechanical College

Symbolic Logic and a Logical Truth Calculator. *J. E. Schwenker*, University of Oklahoma

Photographic Applications of Battery-Capacitor Circuits. *Dan Daggett, Ed Soniat*, The Rice Institute

Saturday, April 19

9:00 a.m. Technical Paper Session III

Homer Coonce, Chairman, Missouri School of Mines Branch, presiding

Adopting the Magnecord Tape Recorder for the Use of Auxiliary Control Tone. *R. M. Cantwell, Jr.*, St. Louis University. (Competing for St. Louis Section prize only)

Magnetic Resonance. *C. D. Watson*, Southern Methodist University

D-C Calculating Board. *L. D. Watkins*, Texas Technological College

Line Losses by the Unit Method. *Leonard Schwobel*, University o Texas

Composite Television Analyzer. *Robert Oxment, R. W. Cotterman*, Washington University

The presentations were excellent and a broad variety of subject matter was covered in the papers. At the banquet held in the Hotel Kingsway on Saturday noon, the following prizes were awarded.

The District Branch First Prize was awarded to A. R. Engquist and R. S. Christy of the University of New Mexico for their paper entitled "Characteristics of the Radion Tube, Preliminary Report."

The District Branch Second Prize consisting of a certificate of honorable mention was awarded to Robert Ozment and R. W. Cotterman of Washington University, St. Louis, Mo., for their paper entitled "Composite Television Analyzer."

Honorable mention also was awarded to C. M. McDowell of the Missouri School of Mines and Metallurgy for his paper, "Multiple-Trace Oscilloscope for Observation of Transients."

In the St. Louis Section Prize Competition with only the schools in Missouri competing, the paper by Messrs. Ozment and Cotterman was awarded first prize, consisting of $20 in cash and a loving cup. Second prize was awarded to C. M. McDowell, which consisted of $10 in cash.

The judges of the District Branch Prize Paper Competition were: H. Weichsel, Consulting Engineer, Wagner Electric Corporation; L. O. Campbell, Superintendent, Electrical Installations Engineering Division of the General Electric Company; and F. R. Small, Toll Practices Supervisor of the Southwestern Bell Telephone Company.

North Eastern District Meeting in Binghamton Exceeds Expectations

The 3-day meeting of the North Eastern District, held in Binghamton, N. Y., April 30–May 2, 1952, with headquarters in the Arlington Hotel, exceeded all expectations for attendance with a total registration of 677 members and guests. The program was highlighted by a symposium on the development of power from the Niagara and St. Lawrence Rivers; an address by James F. Fairman, Administrator of the Defense Electric Power Administration; and appropriate recognition of the 50th Anniversary of the AIEE Ithaca Section. During the 3 days, a broad variety of subject matter was presented in 15 technical sessions, and on Friday a Student Paper Session was held, followed by a luncheon meeting of Student Branch Chairmen and Counselors. Social events included a smoker and a banquet held on successive evenings, while social get-togethers, trips, and entertainment were arranged for the ladies under the chairmanship of Mrs. E. G. Kniffen. Inspection trips were taken to the Goudey Generating Station and to well-known industries in Binghamton and vicinity.

At the District executive meeting held on April 29 announcement was made that prize-winning papers had been selected by the committee, as follows:

First prize: "Gaseous Insulations for High-Voltage Transformers" by Guglielmo Camilli and R. E. Plump, General Electric Company; and G. S. Gordon, Skillman, N. J.

Second Prize: "Sixty-Cycle and Impulse Sparkover of Large Gap Spacings" by J. H. Hagenguth, A. F. Rohlfs, and W. J. Degnan, General Electric Company.

THE BANQUET

At the banquet on Thursday evening, the 50th Anniversary of the Ithaca Section was

commemorated. Dexter M. Kimball, Dean Emeritus, who was on the faculty of Cornell University 50 years ago when the Ithaca Section was formed, and who became the first dean of the Engineering Colleges at the university, acted as toastmaster and reminisced about the early days. Vice-President J. G. Tarboux read a telegram from Dr. Frederick Bedell in California which expressed greetings on the occasion and the esteem of his friendship for Dean Kimball over the years. Dr. Bedell was elected to the AIEE in 1891 when one practically could name all Institute members.

Dean Kimball described the early work of William A. Anthony, Professor of Physics, who had constructed a building known as the Copper Building to house a galvanometer because it was built with copper nails. Later Professor Anthony, together with Professor Moler, constructed a dynamo which, in 1876, was taken to the Centennial Exhibition at Philadelphia where it attracted great interest as the first American dynamo. He also referred to Dr. Thurston, who succeeded Professor Anthony, as a man of great vision and one who was most farsighted in his field. Dr. Thurston quickly recognized that electrical engineering would develop along the lines of power generation and utilization, and under the effective instruction offered, Cornell became recognized as one of the leading schools of electrical engineering in the world, and Dr. Thurston as a world authority on engineering. He was succeeded by Professor Harris J. Ryan, who became the first professor of electrical engineering and head of the department, remaining there for 16 years until called to Leland Stanford University where a high-voltage laboratory was built for him which today bears his name. Professor Ryan was elected the first Chairman of the Ithaca Section in 1902. Dean Kimball's friend of long-standing, Dr. Bedell, wrote, with Crehore, the first book on alternating currents; in 1895 it was translated into practically all of the civilized languages of the world. Another book, by Bedell and Steinmetz, defined all of the fundamental terms, impedance, reactance, inductive reactance, capacitative reactance, admission, and susceptance. Brochures containing the history of the Ithaca Section were distributed among the audience.

A highlight of the banquet was past president James F. Fairman's address, "The Engineer's Role in Defense Mobilization." From a wealth of experience, Mr. Fairman told in a personal vein of the trials and tribulations of life as a public officer in Washington, D. C., as compared to that of the businessman. This gives one a greater appreciation of government efforts than do criticisms which appear in the newspapers and magazines. To maintain good government, we must have the right people in government jobs. In this respect, Mr. Fairman advocated a higher standard of citizenship, and he particularly urged engineers to take a more active interest in their government and try to improve it. If patriotic reasons are not adequate, he drew attention to the fact that the government today is spending a little over 25 per cent of the national income, whereas a little more than a generation ago, it was spending $2^1/_2$ per cent. The address will be published in full in the July issue of *Electrical Engineering*.

Display of future development of Niagara power in the ballroom of the Arlington Hotel during the North Eastern District Meeting attracts, left to right: A. W. Milliken, Vice-President, New York State Electric and Gas Corporation; R. D. Jennison, Chairman of the Board, New York State Electric and Gas Corporation; E. S. Bundy, Vice-President and Chief Engineer, Niagara-Mohawk Power Corporation; J. G. Tarboux, Vice-President, AIEE North Eastern District; and W. W. Perry, General Chairman for the meeting

A cordial welcome to the banquet was extended by W. W. Perry, General Chairman, who expressed appreciation to the manufacturers who made possible the social hours and some of the other features of the meeting.

ENGINEERING ASPECTS OF POWER FROM THE NIAGARA AND ST. LAWRENCE

The engineering aspects of proposed hydroelectric power developments in New York State and Ontario, Canada, were presented from three points of view. The early history and the development of hydroelectric power from the Niagara River through to the ultimate plans for the development of power from the Niagara by the five private companies operating in New York State which would increase the capacity by 1,132,000 kw were given by E. S. Bundy, Vice-President and Chief Engineer, Niagara Mohawk Corporation. The plan described by Mr. Bundy called for the construction of a new plant near Lewiston, N. Y., below the rapids, to take advantage of maximum head of approximately 320 feet, and the construction of three tunnels to obtain water from the upper Niagara River near Conners Island. This plant would have a total installed capacity of 1,080,000 kw and, if desired, would be constructed in three steps with one tunnel for each step to add approximately 330,000 kw per step. The second unit would be a pump storage plant which would add 130,000 kw of installed capacity and a reservoir capable of storing 20,000 acre-feet of water, with pumping during the night hours to preserve the beauty of the Falls. The third unit involves reusing the water from the Schoellkopf Station by means of a tunnel from the Maid of the Mist Pool to a plant near Lewiston which would increase the installed capacity by another 120,000 kw. Because of the long experience with the development of hydroelectric power from the Niagara River, and as the companies have the lines and capabilities to get the power to the customers, Mr. Bundy felt that the job could be done less expensively, more easily, and more quickly by the five private companies.

The second speaker, F. J. Leerburger, Consultant to the New York State Power Authority, explained the engineering aspects of the generation and transmission of power from the St. Lawrence River, which involves construction of a 287,000-volt transmission loop through New York State and New England at an estimated cost of approximately $98,000,000 and the operation of the companies in the area as a power pool. Studies have been made on the network analyzer at Schenectady, N. Y., of the operation of the proposed plan.

The third speaker, R. L. Hearn, General Manager and Chief Engineer, The Hydro-Electric Power Commission of Ontario, presented the Canadian point of view of generation and use of Niagara and St. Lawrence power in Ontario. As background history, Mr. Hearn described the rapid growth and extension of the system in Ontario which he explained had no coal, oil, or gas, and, being fuel deficient, naturally turned to the development of hydroelectric power. The capacity of the Queenstown plant was quickly consumed and, from 1910 to 1939, the Niagara system was extended to Windsor, Huron, and northern Ontario up to James Bay so that today interconnections spread over 1,200 miles. In addition, he told of the costly problem of frequency conversion to 60 cycles which is well underway, but the project will require 10 years' time. At present, they have caught up to the growth of the 25-cycle load and a 60-cycle supply has been put in so that all new customers will be furnished energy at 60 cycles. Mr. Hearn said that the Province of Ontario desperately needs power from the St. Lawrence River and, although the new treaty divides the water on a 50–50 basis between Canada and the United States, the problem had to be treated like any other variable source.

Each of the speakers answered questions from the floor, and as each speaker was introduced a biographical résumé was given by Vice-President Tarboux, who presided.

POWER SESSIONS

Papers presented in 14 other sessions covered practically the whole gamut of the electrical industry. In a Wednesday morning session on distribution for coming power loads and economics, F. S. Black, Editor of *Electrical World*, presented a résumé of the economic forecast for the next 10 years, which was made after an exhaustive study by the McGraw-Hill Company and was published in the May 19th issue of *Electrical World*. With the load to more than double in the next 10 years and a long-term trend of national economy above anything known in the past, Mr. Black explained that planners must look ahead in order to obtain optimum economy from their systems. This served well as an introduction to the papers which followed dealing with economical wire sizes, economical combinations of transformers and secondaries, and distribution performance as an index to economical design.

In another session on power stations and equipment, papers were presented which dealt with the relay protection of a double-circuit winding generator, high integrated fault duty field test on a 69-kv circuit breaker, and the engineering features of a 60,000/75,000-kw reheat unit in the Goudey Station. E. K. Karcher and S. W. Zimmerman presided at these sessions.

Three District papers and two technical papers also were presented on the first morning of the meeting at a session devoted to electronics and servomechanisms, presided over by W. E. Meserve, Cornell University. A. O. Fitzner, Westinghouse Electric Corporation, presented the first District paper, "Solution of Control Problems on the Analogue Computer," in which he described the recently developed Office Computer. This is similar to the Electronic Differential Analyzers and is capable of solving simultaneous linear differential equations of one independent variable and, in some cases, nonlinear equations.

A high-speed linear hydraulic servo valve was described by R. L. Scrafford, Cornell Aeronautical Laboratory, Inc. This valve is capable of being driven by two miniature triodes and has a flow rating of 30 cubic inches per second at a pressure of 2,000 pounds per square inch; the time constant is of the order of 3 milliseconds. An electronic device for testing the timing of camera shutters and their synchronization with flash bulb was explained by R. Lavendar, Ansco Division, General Aniline and Film Corporation, and L. G. Abraham, Jr., Cornell University graduate student, read a paper on a millimicrosecond oscilloscope. The final paper of the session, "Piecewise Linear Servomechanisms," was presented by J. W. Schwartz, also a graduate student at Cornell University.

In the afternoon, a session was held which dealt with the adequacy and quality of service, with A. E. Knowlton presiding. Six papers were presented which treated the following aspects of the subject: distribution design for high-density loading, standard substation design, functional utilization of aerial cable, merits of bus and feeder regulation, capacitor application, and distribution transformer capabilities.

Electricity in aviation was the subject of the session on Wednesday afternoon at which five District papers were presented, which in the main dealt with the use of computers and servomechanisms in the field of aeronautics. R. E. Frazier of the Cornell Aeronautical Laboratory, Inc., described the analogue computer which was designed for moderate precision in solving special problems for military problems, in a paper entitled, "Special-Purpose Analogue Computer for Aircraft Control."

W. W. Wood, Jr., Link Aviation, Inc., read a paper, "The Modern Flight Simulator," in which he reviewed the progress that aircraft instrumentation has made since the early days of flying when the pilot of an airplane had to see the terrain over which he was flying in order to know his whereabouts. Today's pilots are trained to fly by instrument and the Link trainer, which embodies electronic computer principles, provides all the requisites for piloting a modern airplane, even a *B-47*. An instructor can set up flight problems of all kinds on the trainer and the student's performance and solutions of these problems are measured and evaluated.

"Some Practical Aspects of Servoamplifier Design" was presented by R. F. Redemske, Servomechanisms, Inc., in which he considered certain practical influencing factors of an a-c carrier-type electronic servoamplifier for high-performance low-power-output feedback control system. The development of potentiometers was discussed by L. Packard, Technology Instrument Corporation; he described the noise factor and recommended some definitions for use in potentiometer specifications.

The final paper, "The Comparative Advantages of Some Vector Analogues," was given by C. D. Bock, Arma Corporation, in which he discussed the electromagnetic resolver which has the property of showing a percentage error independent of the excitation level. Better accuracy than 1 part in a 1,000 is obtainable over a specified range of 30 to 1 in excitation.

On the following day, other sessions in the central station field dealt with protection and transformer loading with S. O. Schamberger presiding, general power problems with I. B. Johnson presiding, and distribution maintenance with George Fiedler presiding. Standard fuse links, ways to improve transmission-line service, the latest trends in transformer insulation, transformer loading, and a new thermal overload indication on power transformers were among the subjects presented and discussed in the first session. The second session on general power problems was for those more theoretically inclined and treated such subjects as traveling waves on transmission lines, apparatus economy of open-delta transformer banks, capacitance and surface voltage gradient of transmission lines, and the variation at constant density of the dielectric breakdown of paper with air resistance. In the session on distribution maintenance, the location of street lighting trouble was demonstrated and a motion picture was shown of working 13,000-volt lines with hot sticks on the system of the Long Island Lighting Company. Other papers had to do with such subjects as the joint use of poles in the light of increasing line voltages, chemical treatment of the right of way, and what the engineer should know about wood products.

INDUSTRIAL APPLICATIONS

In two sessions on industrial applications with R. O. Bell and E. M. Guyer, respectively, presiding, a variety of subject matter was presented. One paper dealt with the economics of a higher voltage distribution system, 270/480 volts for power and lights in industrial plants and office buildings. Another paper dealt with the selection of a distribution system for industrial plants and the proper factors to consider; flexibility, service continuity, efficiency, regulation, operation and maintenance costs, and investment costs. The author, H. L. McGee, concluded that too much attention is given to investment costs in the initial stages of planning and the system best suited to do the job adequately should be chosen. Still another paper had to do with the important features of power distribution in Westinghouse electronic tube plants where continuity of service and uniform voltage are of the utmost importance. The last paper, presented by V. L. Dzwonczyk, described the intricate problems encountered in the lighting of a network analyzer area where large numbers of readings of light beam instruments have to be taken as well as other work on both horizontal and vertical surfaces which has to be accurately performed.

Papers which were presented in the second session on industrial applications had to do with such subjects as the applications of magnetic amplifiers, economic factors that influence dieselization and electrification of railways, d-c drive for multisectional machines, and the self-excitation of capacitor motors.

On Friday morning H. A. Affel, Bell Telephone Laboratories, presided over the session which was devoted to transistors. The first paper was given by C. L. Roualt, General Electric Company, in which he explained, with the aid of a germanium crystal lattice model, the theory underlying the transistor, its symbolic representation, and the present state of its development. D. M. Powers, Raytheon Manufacturing Company, showed how transistors were employed in amplifiers, giving circuits and their equations when the base, emitter, or collector is grounded. The use of a recently developed nomograph was explained.

The last of the three District papers presented at the session was by A. E. Anderson, Bell Telephone Laboratories, entitled "Transistors in Pulse Circuits." He brought out that the space and power required for a transistor package such as can be used in a regenerative pulse amplifier, a bit register, binary counter, delay amplifier, and so forth, is now approximately one-tenth that of the present vacuum-tube set. It was shown how a transistor and a relay can be incorporated in the same circuit and how the parameters are obtained.

STUDENT PAPER SESSION

Nine papers were presented by the students in competition for the District Branch Paper Prizes under the guidance of Professor W. H. Erickson, Chairman of the District Committee on Student Activities. The papers were required about a month in advance and judged on the basis of the

written text as well as the oral presentation. The program was as follows:

1. "An Electronic Calibrator for Camera Shutters," by Kenneth D. Fastrow, Syracuse University.
2. "A System for the Controlling of Speed of an Aluminum Extrusion," by Stanley D. Kahn, Rensselaer Polytechnic Institute.
3. "Ultra Modulation," by Frank S. Coxe, Yale University.
4. "Power Supply—Zero," by Philip B. Clark, Syracuse University.
5. "Determination of Ambient Temperature in Transformer Testing," by C. E. Colbert, Cornell University.
6. "A New I.L.S. Localizer," by Harold H. Leach, Northeastern University.
7. "An Analogue Computer for Solving Algebraic Equations," by Monroe M. Dickinson, Jr., Worcester Polytechnic Institute.
8. "An Ultrahigh-Frequency Antenna Demonstrator," by Charles F. Merrigan, Rensselaer Polytechnic Institute.
9. "An Instrument for the Measurement of Phase Angle," by Donald C. Loughry, Union College.

STUDENT BRANCH CHAIRMEN AND COUNSELORS LUNCHEON MEETING

The luncheon meeting was called to order by Professor W. H. Erickson, who introduced C. C. Foster, Chairman of the Committee of Judges of Prize Awards. First Prize went to Monroe M. Dickinson, Jr., of Worcester Polytechnic Institute, for his paper entitled "An Analogue Computer for Solving Algebraic Equations." The Second Prize was awarded to Charles F. Merrigan of Rensselaer Polytechnic Institute for the paper entitled "An Ultrahigh-Frequency Antenna Demonstrator." Third Prize also was awarded to a Rensselaer Polytechnic Institute student, Stanley D. Kahn, for his paper, "A System for the Controlling of Speed of an Aluminum Extrusion." On behalf of the RCA Laboratories, Mr. Foster invited the three prize winners and the counselor-elect to a tour of the laboratories in Princeton, N. J.

The student authors were complimented on their written and oral presentations by R. K. Fairley, District Vice-Chairman on the Membership Committee, who also was one of the judges. Mr. Fairley drew attention to the cards which counselors had been asked to fill out and sent to headquarters. These cards will then be sent to the chairmen of Sections where graduating students would be relocated, and it will be seen to that the graduating students get into Section activities. He also suggested that graduating students look at the AIEE Year Book before leaving college and determine the name of the Chairman or the Secretary of the section where they are going after graduation.

Professor Roland G. Porter of Northeastern University was unanimously elected Chairman of the District Committee on Student Activities. As the next meeting of the North Eastern District will be held in Boston, Mass., April 29–May 1, 1953, Professor Porter urged everyone to turn out and present as good a group of papers as were had at the present meeting.

As a suggestion for counselors, it was reported that a series of guidance lectures for sophomores had been successful in a Branch meeting where the faculty could not do it. The suggestion to tell what engineering is all about was originally made or sponsored by John L. Callahan of the RCA Laboratories. Professor Erickson suggested that the students be invited to Section meetings and that some students should go to other schools and present their papers as guest speakers. The meeting concluded with a résumé of experiences by Vice-President Tarboux on visiting a number of the Sections and Student Branches. A total of 95 Branch meetings were held in the District during the year.

COMMITTEES

Members of the General Advisory Committee which made the arrangements were as follows: W. W. Perry, *General Chairman;* J. G. Tarboux, *Vice-Chairman;* E. B. Alexander, *Secretary;* M. S. Hall, *Historian;* R. F. Bovier; G. E. Dana; E. M. Guyer; K. S. Koon; J. P. Peterson; E. F. Wood; and S. W. Zimmerman.

The chairmen of the other committees were as follows: *Budget and Finance,* L. F. McGowan; *Technical Program,* M. S. McIlroy; *Hotel Reservations and Registration,* A. O. Kenyon; *Publicity,* N. L. Platt; *Student Branch Activity,* W. H. Erickson; *50th Anniversary Banquet and Smoker,* J. R. Stover; *Inspection Trips and Transportation,* J. P. Peterson; *Ladies' Entertainment,* Mrs. Earl Kniffen.

Last Call for Subscriptions to Three New AIEE Publications

As announced in *Electrical Engineering* for March (*EE, Mar '52, pp 279–80*), three new publications will be inaugurated, beginning in July, to take the place of the present AIEE *Proceedings.* A subscription card to the new publications and the annual AIEE *Transactions* was sent to the membership in March. Those who have not already filled in and returned this card should do so promptly. The use of the card is preferable to writing a letter. The receipt of all subscriptions in advance will be of assistance in the ordering of proper quantities of paper and the issuance of the publications at optimum economy. The publications are tentatively titled as follows:

Communication and Electronics
Applications and Industry
Power Apparatus and Systems

Each of the publications will be issued bimonthly beginning with *Communication and Electronics* and *Applications and Industry* in July. *Power Apparatus and Systems* will be issued on alternate months. All subscriptions will be on an annual basis. A listing of the subject matter to appear in each of the three new publications and the months of issue is given in Table I.

Member Subscriptions. Each member will have the option to elect to receive in consideration of payment of dues without additional charge one of the three bimonthly publications. Additional publications may be obtained by members at an annual subscription price of $2.50 each.

Nonmember Subscriptions. Nonmembers may subscribe to any of the three publications on an advance annual subscription basis of $5.00 each (plus 50 cents extra for foreign postage payable in advance in New York exchange). A discount of 25 per cent will be allowed to college and public libraries. Publishers and subscription agencies may be allowed a discount of 15 per cent. Single copies may be obtained when available at $1.00 each.

Each of the new publications will include only the formal papers which have been presented at meetings and which have been recommended for publication in *Transactions.*

AIEE Annual Transactions

With the adoption of a divisional plan of publication, the bound volumes of *Transactions* beginning with Volume 71, 1952, instead of being issued semiannually, will be issued annually (early in 1953) in three parts as follows:

AIEE *Transactions*
Part 1. *Communication and Electronics*
AIEE *Transactions*
Part 2. *Applications and Industry*
AIEE *Transactions*
Part 3. *Power Apparatus and Systems*

Each part of the *Transactions,* bound in cloth with a stiff cover at the end of the year, will have the identical contents as the corresponding six issues of the bimonthly publication. Savings will be effected by overprinting the pages for *Transactions* at the same time the bimonthly publications are printed and there will be less spoilage of paper.

Member Subscriptions. A combination subscription to all three parts of *Transactions* beginning with Volume 71, 1952, is offered to members at a price of $6.00 per year. Members may subscribe to any one part at a price of $3.00 per year. A subscription card will be sent to all members, and the placing of subscriptions should be deferred until that time.

Nonmember Subscriptions. An advance combination subscription to all three parts of *Transactions* beginning with Volume 71, 1952, is offered to nonmembers at a price of $12.00 per year payable in advance (plus $1.00 extra for foreign postage payable in advance in New York exchange).

An advance combination subscription to any two parts of *Transactions* beginning with Volume 71, 1952, is offered to nonmembers at a price of $10.00 per year (plus $1.00 extra for foreign postage payable in advance in New York exchange).

An advance subscription to any one of the three parts of *Transactions* beginning with Volume 71, 1952, is offered to nonmembers at a price of $6.00 per year (plus 75 cents extra for foreign postage payable in advance in New York exchange).

A discount of 25 per cent will be allowed

Table I. Months of Issue and Subject Matter to Appear in Each of Three New Publications Tentatively Titled

Communication and Electronics July, Sept., Nov., Jan., March, May	Applications and Industry July, Sept., Nov., Jan., March, May	Power Apparatus and Systems Aug., Oct., Dec., Feb., April, June
Communication Switching Systems	Air Transportation	Carrier Current
Radio Communications Systems	Domestic and Commercial Applications	Insulated Conductors
Special Communications Applications	Land Transportation	Power Generation
Telegraph Systems	Marine Transportation	Protective Devices
Television and Aural Broadcasting Systems	Production and Application of Light	Relays
Wire Communications Systems	Chemical, Electrochemical, and Electrothermal Applications	Rotating Machinery
Basic Sciences	Electric Heating	Substations
Computing Devices	Electric Welding	Switchgear
Electrical Techniques in Medicine and Biology	Feedback Control Systems	System Engineering
Electronic Power Converters	General Industry Applications	Transformers
Electronics	Industrial Control	Transmission and Distribution
Instruments and Measurements	Industrial Power Systems	
Magnetic Amplifiers	Mining and Metal Industry	Education
Metallic Rectifiers		Safety
Nucleonics		Research

on all three nonmember subscriptions to college and public libraries. Publishers and subscription agencies may be allowed a discount of 15 per cent.

All subscriptions to any of the publications and remittances should be sent to AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

Textile Processing Provides Theme for AIEE Conference in Germantown

The 1-day AIEE Northern Textile Conference was held at the Philadelphia Textile Institute, Germantown, Pa., on April 24, 1952. "Textile Processing—Toward a Science" was the theme of the conference, which was attended by about 80 members and guests. Five papers were presented at the two sessions, the afternoon session closing with a discussion of intense interest to the textile manufacturing industry. This conference was sponsored by the AIEE Textile Committee, the Philadelphia Textile Institute, and the AIEE Philadelphia Section, of which H. H. Sheppard is chairman.

The morning session was called to order by J. M. Bracken, American Viscose Corporation, who introduced B. W. Hayward, Director, Philadelphia Textile Institute, who, in turn, welcomed the visitors to the modern school.

The first paper, "Stroboscopic Measurements in Textiles," was presented by W. R. Saylor, General Radio Corporation. After describing the flashing light source, which has a calibrated range varying from 60 to 14,400 flashes per minute, the author described some of the lamp's uses in textile manufacturing. In the spinning room, for example, spindle speeds can be easily calculated and checked and causes of speed deviations can be determined: misaligned or worn spindles, which can be located by their vibration; crooked or worn bobbins; slap of the balloon; sluffing and other yarn defects; action of the rings and travelers, and so forth.

In the weave room the picking, shedding, and lay mechanisms of the loom operate at a repetition rate from about 60 to 250 per minute. To obtain synchronization of the light flashes with different positions of the shuttle leaving or entering the boxes, along the shed, and so forth, a magnetic contactor is attached to the camshaft or crankshaft. This enables the light to be flashed each time the camshaft, for example, returns to a given position and by means of a variable control the relative timing of the flashes and the shaft can be changed so that the shuttle can be "stopped" at any point in its travel. Similarly, motions of other parts of the loom—the picker stick, the lay, check straps, bumper straps, and so forth—can be studied, timed, and measured.

These motions can be photographed with an ordinary camera and the stroboscopic light, which can be varied in intensity from 4,000 beam-candles to a peak of 9,000,000 with an intermediate point of 150,000 beam-candles.

William Phillips, Leeds and Northrup Company, presented "An Automatically Calibrated Speed Measuring System Operating on a Frequency Basis." After explaining the disadvantages of other devices for measuring small variations in speed, the speaker explained a recently developed system which operates on a frequency basis—a high-speed electronic type of recorder with a crystal-controlled oscillator. After filtering the input voltage for attenuating the harmonics and maintaining a constant output voltage, there are limiter stages which hold amplitude changes to a minimum. The frequency is then doubled and differenttiated where pulses are formed with a short time constant. After being amplified and rectified, the positive pulses go to a capacitor where they are counted. The indicating device is a meter with a 2-cycle range that can be set anywhere between 10 and 130 cycles.

The final paper of the morning session was given by R. E. Parker, General Electric Company, its title being "Tension Measurement in Spinning." The simplest way to measure tension is to deflect the end between the front rolls of the spinning frame and the guide just as the spinner would check the tension with his finger. As only a little deflection will cause an end down, small differences in the amount of deflection will affect the reading as the tension is proportional to small deflections. However, a device will measure the tension here, but great care is necessary in its use. Another instrument is the dancer-roll type of tensiometer, but this device cannot be used on a spinning frame because the twist cannot get through to the front rolls and the end breaks.

A compromise between the two methods mentioned is the use of the yarn guide to sense the tension. The resistance type of strain gauge attached to a thin strip of metal is used, which will bend slightly under the influence of the yarn tension. This can be used only for short periods of time; for long periods a magnetic type of strain gauge is preferable. Here again a metal strip is made to deflect proportionally to the yarn tension, but it is placed between two magnetic strain-gauge coils so that its motion changes the air-gap reluctance to alter the current in the coils. Suitably amplified, this current provides an indication proportional to the yarn tension.

It is preferable to measure the tension of several ends to get an average for the entire frame, thus avoiding random factors such as a slub on the traveler, tape slip, and so forth, which would give a false indication of normal condition for the entire frame if taken singly.

BOUVET TALKS AT LUNCHEON

At the conclusion of the luncheon at nearby Alden Park Manor, Rene Bouvet, American Viscose Corporation, spoke on "The Swift Progress in the Textile Industry." Although the textile industry is centuries old—beautiful silk was woven in China about 4,000 years ago—a great change has occurred within the past 50 years. At the start of this century, it was customary to have a weaver take care of four looms; now one person runs anywhere from 40 to 100 looms at a greater efficiency.

In discussing synthetic fabrics, the speaker mentioned that rayon,' which had been produced first in Europe about 1900, made its appearance here about 10 years later and its consumption has grown from less than a million pounds per year to more than a billion pounds in 1951. The United States is far ahead of European manu-

facturers in producing viscose and acetate yarns as the Europeans do not have the basic fiber nor the equipment. In the past 40 years more than 20 new fibers have been discovered and are being produced.

Mr. Bouvet showed samples of the various fabrics as he described them and the properties of the fibers which were used in their make-up. He concluded with the statement that the great advances made in the textile industry were due solely to the enormous amount of research which was being conducted.

Upon returning to the Philadelphia Textile Institute after luncheon, the members were taken on a tour of the classrooms and laboratories where they saw the latest in textile machinery in operation.

AFTERNOON SESSION

A. W. Frankenfield, E. I. Du Pont de Nemours and Company, was the chairman of the afternoon session. The first paper, "Loom Desynchronizing," was presented by F. D. Snyder, Westinghouse Electric Corporation. It was explained how a great number of looms operating in synchronism on upper floors of a building could cause damage to the building just as soldiers marching in step across a bridge would cause it to collapse. The trouble is due to the looms being exactly in step as far as their lay positions are concerned: when large numbers of lays are started in the same direction at the same time, huge resultant forces are exerted on the building. When the lays are stopped, the same force is exerted in the opposite direction.

If the lays of two rows of looms in a weave room could be made to move in opposite directions simultaneously, the forces would be opposing and the result would be zero. An electrical scheme has been developed whereby two facing looms will operate at a fixed predetermined crankshaft-position relationship one to the other. Any scheme to keep two sets of looms 180 degrees out of phase must be able first to detect that one loom is going faster than the other, and then take corrective action to keep the looms at the same speed. Either of the two looms must be able to be started and stopped without affecting the other's operation and the speed of the loom must not be reduced at the instant of picking or beat-up, as this might cause faulty picking or a mark in the fabric.

The apparatus involved is a magnetic switch for each loom, replacing the present manual switch; a maintained contact start-stop master switch for each loom; a 12-volt-ampere stop transformer for a pair of looms; a single-pole, normally closed contact, 12-volt coil relay for each loom; and a crankshaft-operated switch for each loom, the equivalent of a single-pole double-throw switch with a neutral position.

The cycle of operations is too long to describe here, but briefly, when one loom runs ahead of the other so that it tends to get in step, the faster loom is slowed momentarily by the crankshaft motion for as many cycles as necessary to bring the faster loom's speed down to where it is 180 degrees out of phase again.

The second paper of the session, "Vibration Control of High-Speed Twister Spindles," was given by H. H. Wormser, Universal Winding Company. One of the main problems of the textile industry is vibration of twister spindles. This power consuming vibration can be due to several causes but one of the most likely is unbalanced bobbins which rotate at high speeds on the spindles. Although well-balanced bobbins are on the market, there are too many still usable, although unbalanced, for the industry to replace economically. For this reason, a bobbin balance indicator has been developed which is an inspection unit to show which bobbins are in greatest need of balance correction. It can be used to grade bobbins in terms of the vibration they cause and to indicate those which should be replaced or balanced. By using two spindles in turn, 300 to 500 bobbins can be checked in an hour.

The indicator is really a spindle vibration meter. Two spindles are mounted in it so that their bolster movements reflect the vibration a bobbin causes on a spindle. This impulse causes a current flow in a magnetic pickup, which is amplified and shown on a meter. As no such measurements had been made heretofore, a unit of unbalance had to be established as a measuring stick for effective bobbin unbalance. This unit in terms of standard units is defined as 10 universal units of unbalance is that unbalance caused by 10 inch-grains of unbalance in each head on opposite sides of a bobbin with a 3-inch diameter head, a 5-inch long traverse, a $1^5/_8$-inch diameter barrel weighing 8 ounces. It has been found with this indicator that between 5 and 10 per cent of the bobbins generally should be discarded, and although it is still in the development stage, it has promise.

DISCUSSION

After the concluding paper, a discussion was conducted on "Textile Motor-Control Enclosures for Lint Atmospheres." After pointing out how lint and fly entered into enclosures through different cracks and holes and so could short-circuit the electric apparatus within them, the members were requested to write their opinions on the following questions:

1. Shall enclosures be so constructed that they will keep lint out of, and prevent the escape of sparks from, the interior?
2. Shall completely assembled unmounted devices' enclosures have no unused mounting holes?
3*A*. Should there be conduit knockouts?
3*B*. Should there be suggested locations for conduit knockouts marked on the enclosure?
4. Should the overload reset button be a separate device which should be operable only by opening the enclosure?
5. Should enclosures have sufficient room on each side of the enclosed mechanism for all connecting wires of the proper size?
6. Should latches (wing nuts or screws) be provided which are positive and reliable?
7. Which of the enclosures exhibited at the conference would be preferable?

The results of this poll will be combined with the answers to similar questions asked at the Textile Conference held at Atlanta, Ga., May 1 and 2, and the results will be taken to the National Electrical Manufacturers Association for action.

P. G. Wallace Reports Dallas Service Providing Guidance for Future Engineers

The growing need for engineers since World War II has focussed attention on the alarmingly small number that are being graduated from the technical colleges and universities. Several organizations, namely, the Engineers Council for Professional Development, and the various State Societies of Professional Engineers, have been attempting through correspondence to guide high-school graduates into various engineering fields. The real need, however, is for a guidance service on a community level that will provide a closer contact between the professional engineers and the students.

According to Mr. Wallace, Head, Design Division, Engineering Department, Texas Power and Light Company, Dallas, a vocational guidance and counseling service in Dallas known as "The Dallas Community Guidance Service" (nonprofit organization) for senior high-school boys and young men has just completed its fifth year. This unique service was established in February 1947, by the Honorable George C. McGee, present United States Ambassador to Turkey, and was chartered in April of that year by the State of Texas for the purpose of furnishing a program of guidance and counseling to young men and boys of Dallas County.

In establishing a foundation for the financing of this service, Mr. McGee stated that he felt such a service would be of invaluable assistance to a great many high-school boys in their search for a profession or business which would coincide with their interests and abilities. His observations had indicated to him that the cause of most failures is unhappiness of young men in their business or profession because they had not used true values in the choices which they made in the selection of their vocations.

During the 5 years that the service has functioned, every boy who has been graduated from the senior high schools in Greater Dallas has been interviewed personally by a man trained in vocational guidance work, and those boys interested in engineering have received further counseling, aptitude and interest tests, and advice from professional engineers practicing in the various fields of engineering. This phase of the program is divided into two parts. The first part consists of a panel of engineers from the various fields meeting with each high-school group of students desiring to become engineers. In this meeting an outline of suggested questions and answers is given to each student in advance of the meeting, and during the meeting these questions are discussed in detail. By using the outline the discussions are channeled along the lines considered most beneficial to the students. The second phase of the program consists of a weekly 30-minute

Management	6	Nuclear Physics	3
Mechanical	22	Structural	6
Petroleum	21	Undecided	25
		Total	216

The overwhelming success of the meeting indicates that a similar program will be provided each year, and that the professional engineers through the Community Guidance Service have developed a way of breaching a gap between themselves and high-school students willing to become engineers.

Professional engineers of Dallas, Tex., play host at banquet to 216 high-school students interested in engineering

broadcast over one of the local radio stations. This program is in the form of a panel discussion, with four professional engineers and four selected students, and a moderator. More than 700 businessmen representing the various professional engineering societies and service clubs have volunteered their services in counseling with the boys. Many scholarships have been made available, and loan funds established for deserving boys dependent upon their own resources. Loans totaling more than $100,000 have been made to 259 deserving young men during the 5-year period to finance their college education.

In order to form a closer relationship with high-school students interested in engineering, Founder Engineering Societies of Dallas, in co-operation with the Texas Society of Professional Engineers, held a "Get-Together Banquet" on April 18, 1952, which was attended by 216 high-school seniors selected by the Guidance Service. Their names, telephone numbers, addresses, and chosen fields of higher education, were given to the banquet committee, who in turn assigned a professional engineer from the student's chosen engineering field to each boy. The engineer invited the boy to be his guest at the banquet.

During the evening the students were given every opportunity to discuss with their hosts subjects concerning their chosen field of engineering. An address by Dr. William D. Houston, President of Rice Institute at Houston, Tex., further enlightened the boys on the history of engineering, and the opportunities engineering holds for them in the future.

The following shows the diversity of the divisions of engineering which the boys selected, and the number for each division:

Aeronautical	20	Agricultural	16
Architectural	22	Chemical	19
Civil	14	Design	2
Electrical	33	Geology, Geophysical	7

Further Contributions Invited to Bennett Fellowship Fund

Last January, a memorial fellowship fund was established in memory of Edward Bennett, 1876–1951, professor emeritus of electrical engineering at the University of Wisconsin, Madison. The fund was established at the suggestion of many electrical engineering alumni of the university, and was endorsed by the Milwaukee, Rock River Valley, Madison, and Fox River Valley Sections of the AIEE. Mr. Bennett, a Member for Life of the Institute, died on January 10, 1951 (*EE, Apr '51, p 367*).

Establishment of the fund offers engineers an opportunity to honor the memory of an outstanding engineer and educator. As of April 10, 1952, contributions totalling $1,428 have been received from 64 contributors, with individual amounts varying from $1 to $200. Contributions are still being received and are welcome at any time. All checks should be made out to the University of Wisconsin and mailed to A. W. Peterson, Vice-President of Business and Finance, and Trust Officer, University of Wisconsin, Madison 6, Wis.

North Texas Section Meets in Fort Worth

The April meeting of the AIEE North Texas Section was a dinner meeting held in Fort Worth on the evening of the 24th, and was attended by some 125 persons. Shown here are, front row, left to right: O. S. Hockaday, master of ceremonies for the meeting; H. L. Melvin of Ebasco Services, New York, N. Y., who discussed "A Power Program for Greece"; B. M. Gallaher, Meetings and Papers Committee. Karl Ratliff, Chairman of the Fort Worth Subsection; W. C. Fowler, Arrangements Committee; J. L. Pratt, Chairman-elect of the North Texas Section; E. W. Rogers, Chairman of the North Texas Section

North Carolina Section Meets at Duke Power Company Plant

Approximately 400 members and guests of the AIEE North Carolina Section attended its semiannual (spring) meeting on April 10, 1952, at the Duke Power Company Riverbend Steam Plant near Charlotte, N. C. The meeting was opened by B. V. Martin, Chairman of the North Carolina Section.

Main speaker of the meeting was David Nabow, Director and Chief Designing Engineer for the Duke Power Company, who discussed "Trends in Modern Steam Plants." In his address at the dinner on Wednesday evening, Mr. Nabow described the advantages and disadvantages of hydroelectric power generation and steam power generation. He pointed out that in order to assure continuity of service, dependence must be placed primarily on large efficient steam plants to carry the bulk of the load. In addition, the meeting featured the following papers which were presented at the afternoon technical session:

"Electric Analogue for Determining the Radioactivity of Primary Fission Products With Intermittent Reactor Operation," by W. O. Doggett, North Carolina State College

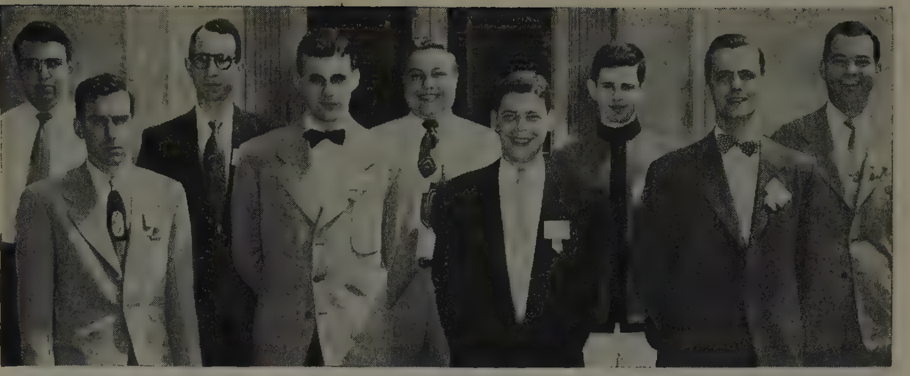
"Operation of a Steam Plant," by E. E. Williams, Duke Power Company

"Operation of an Electric Power System," by H. B. Wolf, Duke Power Company

"Microwave Applied to a Power Company," by W. J. Wortman, Duke Power Company

During the business session, W. C. Burnett, Southern Bell Telephone Company, the present Secretary-Treasurer of the North Carolina Section, was elected Chairman for the coming year, while Professor C. R. Vail of Duke University will succeed him as Secretary-Treasurer. Newly elected to the Executive Committee were: J. A. Jones, Carolina Power and Light Company; E. I. Smith, Atlantic Coast Line Railroad Company; and H. W. Oetinger, Duke Power Company. Presentation of Fellow Awards was made by Professor W. J. Seeley of Duke University to Mr. Oetinger and to B. L. Stemmons, Duke Power Company.

In attendance at the meeting was E. S. Lammers, AIEE Vice-President from Atlanta, Ga.



Presenting papers at the 1952 Southern District Student Conference in New Orleans were, front row, left to right: M. J. Wiggins, University of Florida; J. A. Owens, University of Kentucky; W. D. Barkhau, University of Kentucky; A. W. Vernon, North Carolina State College. Back row, left to right: D. C. McIntosh, University of Louisville; G. L. McMurtray, Tulane University; R. J. Mudd, University of Louisville; L. C. Delisio, Virginia Military Institute; C. H. Saunders, Jr., North Carolina State College

Attendance Exceeds 500 at Third Conference on Electric Welding

The third Conference on Electric Welding, held in Detroit, Mich., April 16–18, 1952, was an outstanding success, both in the quality of new material presented and in the number of engineers attending the sessions. This conference was sponsored jointly by the AIEE, the American Welding Society, and the Industrial Engineers Society of Detroit, and was held in the Rackham Memorial Building. Total attendance at the sessions reached just over 500, an increase of over 20 per cent above the previous conference of 1950. A sizable contingent from the West Coast aircraft industry was present, as well as many from Canada and the New England areas.

A total of 25 papers were presented at six sessions: on quality control; instrumentation; power supply for resistance welding machines; resistance welding; fundamental arc research; and arc welding. Attendance per session ran from 120 to 260 persons with the highest interest in the resistance welding and power supply sessions on Thursday.

This conference also marked the issuance of the new report "Power Supply for Resistance Welding Machines" which is the result of several years work by a special subcommittee of the AIEE Committee on Electric Welding. This report gathers all important fundamental data on resistance welders, types, characteristics, and power supply for them not only from the viewpoints of the user and the manufacturer, but also the utility supply company. In 60 pages are compressed basic data enough to allow any engineer to make any but the most unusual welder application. One session of the conference was utilized to explain the compilation further and compare it to previous reports.

In addition to the regular sessions, an evening meeting was held on Friday jointly with the Detroit Section of the American Welding Society, at which Walter Richter, a consulting engineer of Milwaukee, spoke on "Instrumentation From the Viewpoint of the User." Following the discussion period, the meeting was adjourned to the exhibition floor for demonstrations of the equipment being shown.

As in the past, an exhibition and demonstration of welding equipment and latest techniques was held on the exhibition floor evenings during the conference. Eighteen manufacturing companies participated with a good range of equipment and processes represented.

The committee responsible for details of this third welding conference was under the chairmanship of C. N. Clark of Pittsburgh, with G. W. Garman as Treasurer, and S. W Luther as Chairman of the local committee. The Papers Committee was headed by E. J. Limpel; C. H. Rhoades is in charge of publishing the conference report. Dr. A. Di Guilio was in charge of exhibits, with S. H. Brams and J. S. Francis arranging publicity. Others who were largely responsible for the innumerable details included W. P. Kramer, T. F. Ellis, E. Beck, A. C. Good, A. H. Halem, A. Magagna, and J. F. Deffenbaugh, together with many others on their committees.

Tulane Is Host School for District 4 Student Conference

Tulane University of New Orleans, La., was host school for the annual Southern District (4) Student Conference held April 16–19, 1952. The participating schools were well represented by 136 persons registered.

The conference opened at noon on Wednesday with registration which was followed by guided tours of the Tulane campus including the Sugar Bowl Stadium. Later the same evening, at a stag smoker, Dean Lee Johnson, of the College of Engineering, welcomed the delegates to the campus.

At paper sessions held Thursday and Friday mornings, April 17–18, nine papers were presented. First-place honors went to M. J. Wiggins, University of Florida, for his paper, "Magnetic Tape Sound for 16-Millimeter Motion Pictures." The paper entitled "A Push-Button Telephone Dialing System" won second place for M. L. Barnett of North Carolina State College. Third-place honors were won by J. A. Owens, University of Kentucky, for presentation of "A Phase Scale Generator for Power-Frequency Waveforms."

On Thursday while the paper session was in progress, a coffee party was given in honor of the visiting ladies, and on the following morning they were escorted on a tour of the Vieux Carre.

The afternoons following the paper sessions were spent in industrial tours, including visits to a nearby sugar refinery and the local television broadcasting studio and a ride down the Mississippi River to view the harbor facilities of one of America's largest ports.

Thursday evening, the annual banquet was held at Arnaud's, one of New Orleans' world-famous French restaurants. Dr. Joseph C. Morris, Vice-President of Tulane University and renowned physicist, addressed the gathering on "Stockpiling of Scientific Brainpower." A moonlight dance aboard a Mississippi river steamer highlighted Friday night.

The conference adjourned on Saturday morning after the business meeting. At this session unanimous ballots were cast to have the 1953 conference in Louisville, Ky., with Professor M. G. Northrop, University of Louisville, as the 1953 Chairman of the District 4 Committee on Student Activities.

Fortescue Fellowship Awards Announced for Year 1952-53

The Charles LeGeyt Fortescue Fellowship Committee of the Institute has awarded fellowships for graduate study in electrical engineering during the academic year 1952–53 to Amar G. Bose and James E. Shea.

Mr. Bose is a student at the Massachusetts Institute of Technology with communication engineering as his major subject. He expects to engage in graduate study at that institution.

Mr. Shea is at present working toward a degree of master of science at the University of Connecticut, and expects to engage in graduate study toward the degree of doctor of engineering at Yale University. He is a member of honorary fraternities: Tau Beta Pi, Eta Kappa Nu, and Gamma Chi Epsilon.

The fellowships were established through a trust fund set up by the Westinghouse Electric Corporation in recognition of Mr.

The AIEE Tampa Section holds a nontechnical meeting to celebrate its change from Subsection status

Fortescue's valuable contributions to the electric power industry, and are awarded by a committee of the AIEE.

Tampa Section Celebrates Change from Subsection Status

Members of the AIEE Tampa (Fla.) Section held their first meeting as a full Section on March 21, 1952. This was a nontechnical meeting for the purpose of celebrating the change from Subsection to Section standing of the Tampa group.

Ladies were invited to the meeting which featured entertainment and dancing, with R. E. Oakes, inventor of such items as hydraulic cigarette lighters and self-finding golf balls, as the special attraction. Also present were Professor John Wilson and Dr. Fred Pumphrey. Dr. Pumphrey presided at the installation of officers.

The officers of the previous Tampa Subsection were retained for the remainder of their term, and a nominating committee was appointed to nominate officers for the coming year. Present officers are: J. A. Turner, Chairman; I. L. Garcia, Vice-Chairman; B. N. Darlington, Secretary and Treasurer.

Philadelphia Section Reports Women's Auxiliary Activities

According to a recent announcement, the Women's Auxiliary to the AIEE Philadelphia (Pa.) Section has doubled in size since its initial meeting on April 1, 1948. The membership has now reached a total of 117.

Luncheons and meetings which are held at the Engineers' Club in Philadelphia five times a year have been very successful and well attended. The first meeting this year featured a "Get-Acquainted Card Party" at which new members were introduced.

The Philadelphia Section Auxiliary members were guests of the Women's Auxiliary of The American Society of Mechanical Engineers (ASME) at the March luncheon and meeting of the latter group. This afforded an opportunity for the AIEE women to enlarge their acquaintanceship and establish friendly contacts with the older ASME organization.

At the Telemetering Conference and the Joint AIEE-Institute of Radio Engineers Computer Conference held in Philadelphia, AIEE Auxiliary members had charge of the information and hospitality desks, handed out sight-seeing booklets, and helped those from out of town plan their trips around the city. They also have helped with the programs for both children and adults at AIEE picnics and have sponsored entertainment and prizes for the Philadelphia Section annual dinner-dances.

The Women's Auxiliary has been entirely self-supporting. An annual card party to which the men of the Section are invited furnishes program and publicity expenses for the year.

Plans are now under way for an interesting and active program for next year.

Rubber and Plastics Subcommittee Holds Fourth Annual Conference

An enthusiastic reception was accorded the program presented by the AIEE Rubber and Plastics Subcommittee on Monday, April 28, in the Portage Hotel, Akron, Ohio. Attendance at the meeting was 175, with nearly all present for a luncheon served at 12 noon.

Eight exceptionally interesting papers were presented on various subjects, including rectifiers, adjustable-voltage drives, electronic controls, and magnetic amplifiers. A beta-ray thickness gauge was described, and one paper dealt with a complete rubber calender train installation.

Despite frequent curtailment to allow time for all scheduled speakers, spontaneous discussion and questions followed each paper. It was generally felt that more time might have been allotted to a program of this length and importance.

Complete proceedings of the meeting will be published in booklet form and will be available from AIEE headquarters.

Recording, Controlling Instruments Will Be Subject of Conference

The AIEE Subcommittee on Electrically Operated Recording and Controlling Instruments is planning a 2-day special technical conference to be held in Philadelphia, Pa., at the Benjamin Franklin Hotel, November 17–18, 1952.

The purpose of this conference is to educate and stimulate interest in the design, theory o operation, and application of electrically operated recording and controlling instruments, to familiarize engineers with the recent advances in the metering and control of industrial processes which has been made possible largely by the utilization of new electrical recording and controlling techniques.

Conference papers on the subject should be submitted to the Technical Program Committee Chairman, A. J. Hornfeck, Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, before July 17, 1952.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Division

Committee on Electric Welding (*C. N. Clark, Chairman; E. J. Limpel, Vice-Chairman; J. F. Deffenbaugh, Secretary*). A new Subcommittee on Instrumentation for Resistance Welding has been organized to deal primarily with the application of various instruments to electric welding. The membership was drawn from the Electric Welding Committee, outside industry, and representatives of other interested groups, including American Welding Society, National Electrical Manufacturers Association, and the AIEE Instruments and Measurements Committee.

The Subcommittee on Fundamental Electric Arc Research has reported the completion of the first step in the preparation of a new "Bibliography on Electric Arcs." The first compilation contains approximately 1,200 entries, arranged in alphabetical order by author. Many more entries are yet to be included, both domestic and foreign.

An important new report has been prepared and published on "Power Supply for Resistance Welding Machines" by a subcommittee of the same name. The report supplies a need of the industry, and contains much valuable material on this subject, as furnished by manufacturers of resistance welding equipment, by the utilities which supply the energy for welding, and by the users of welding equipment and processes.

Power Division

Subcommittee on Speed Governing of the Power Generation Committee (*J. B. McClure, Chairman*). Two joint sessions are

being planned for the 1953 Winter General Meeting with the Control Subcommittee of the Systems Engineering Committee. Modern governor characteristics will be reviewed and emphasized; incremental regulation and incremental heat ratios will be stressed; system loading practices will be reviewed, together with an up-to-date story on automatic load control equipment and the ability of turbines and boilers to accept load changes. A joint working group has reviewed possible subject matter and papers are being solicited.

Mr. Steinberg reviewed the work of the joint American Society of Mechanical Engineers (ASME)-AIEE Committee on Speed Governing Specifications, of which he is chairman. This committee was organized in August 1941, under the joint sponsorship of the AIEE Committee on Power Generation (six members) and the ASME Power Test Codes Committee (five members). The original assignment was the preparation of a specification for the speed governing of steam turbine generators rated at 10,000 kw and above. The scope was subsequently enlarged to include turbines rated not less than 500 kw, and to include automatic and nonautomatic extraction turbines. This specification is now available as AIEE Standard 600 (May 1949).

A specification along parallel lines was prepared for hydraulic turbine generators, and is available as AIEE Standard 605 (September 1950).

Committee on Rotating Machinery (*C. G. Veinott, Chairman; E. I. Pollard, Vice-Chairman; L. W. Buchanan, Secretary*). The Synchronous Machinery Subcommittee has formed a working group to prepare an operating guide for large generators. AIEE Standard 502, "Test Code for Single-Phase Motors," is being revised by the Single-Phase and Fractional-Horsepower Subcommittee. Members of the D-C Machinery Subcommittee, working as part of a Joint Subcommittee on Carbon Brushes, have prepared "A Test Code for Carbon Brushes."

The new Electric Coupling Subcommittee has been quite active during the year it has been in existence. A bibliography has been completed, and work is being done on standard definitions and methods of rating couplings.

A group has been formed to study per-unit definitions for all types of rotating machines.

Science and Electronics Division

Committee on Magnetic Amplifiers (*E. L. Harder, Chairman; W. J. Dornhoefer, Vice-Chairman; E. V. Weir, Secretary*). The Materials Subcommittee of the Magnetic Amplifiers Committee has been especially active both in establishing standardized core dimensions, frequencies, and magnetizations for core testing in the committee, and also in the sponsoring of technical conference sessions. The series of eight papers, four of which were joint with the Basic Sciences Committee at the recent Winter General Meeting, covered all phases of the application of oriented nickel-iron alloys and ferrites. A similar treatment of rectifiers is planned next.

Another subcommittee is obtaining lists of persons particularly interested in magnetic amplifiers to whom questionnaires can be sent, and who may be available for membership, discussion, papers, and so on. Persons wishing to be on this list should communicate with A. O. Black, Magnetics Inc., Butler, Pa.

Chief function of the Application Committee is to encourage application papers and provide sessions where they may be brought together. It is also the committee's purpose to encourage application papers on magnetic amplifiers in the other committees of the Institute so that the advances in this new field may be brought to the attention of all interested. Also, papers usually can be provided for District meetings if desired.

Magnetic amplifiers are strongly dependent on nonlinear circuit theory and a number of the committee members are vitally interested in the theoretical aspects themselves. The recently formed Nonlinear Circuit Subcommittee is functioning at present through limited committee meetings in which a mutual understanding of the current theoretical methods and their assumptions can be obtained. Later on it is felt that a useful public AIEE presentation can be made of the results.

Newest of the group is the recently formed Dielectric Amplifiers Subcommittee, which due to the interest of a large part of the membership and the close similarity between magnetic and dielectric amplifier technology, has been placed under the Magnetic Amplifier Committee.

Committee on Electronic Power Converters (*I. K. Dortort, Chairman; C. R. Marcum, Vice-Chairman; J. B. Pitman, Secretary*). The Papers and Speakers Subcommittee, according to present plans, is scheduled to begin a printed supplement to the "Bibliography on Electronic Power Converters" in 1954. An interim supplement, for the years 1948, 1949, and 1950, has been distributed among the members of the Electronic Power Converter Committee.

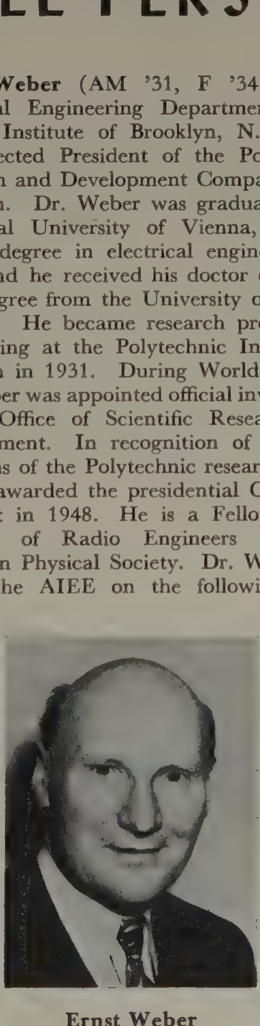
Confirming the suggestion offered at the January 22 meeting of the Electronic Power Converter Committee, there appears to be definite evidence that the problem of the high voltages that can be developed between transformer phases when shutting down an aluminum potline requires further investigation.

A new working group has been appointed to review all American Standards for rectifiers and switchgear.

The International Electric Conference (IEC) will meet in Philadelphia, Pa., in 1954, with the American Standards Association (ASA) as host. World Standards for "Pool-Cathode Mercury-Arc Power Converters," which are almost in agreement with ASA Standards, are ready for adoption. The ASA wishes a delegate from the Electronic Power Converter Committee to Committee *22* of the IEC. The American delegate will be spokesman for the entire United States.

AIEE PERSONALITIES.....

Ernst Weber (AM '31, F '34), Head, Electrical Engineering Department, Polytechnic Institute of Brooklyn, N. Y., has been elected President of the Polytechnic Research and Development Company, Inc., Brooklyn. Dr. Weber was graduated from Technical University of Vienna, Austria, with a degree in electrical engineering in 1924, and he received his doctor of philosophy degree from the University of Vienna in 1926. He became research professor of engineering at the Polytechnic Institute of Brooklyn in 1931. During World War II, Dr. Weber was appointed official investigator of the Office of Scientific Research and Development. In recognition of the contributions of the Polytechnic research group he was awarded the presidential Certificate of Merit in 1948. He is a Fellow of the Institute of Radio Engineers and the American Physical Society. Dr. Weber has served the AIEE on the following committees: Basic Sciences (1935–47); Research (1935–39); and Instruments and Measurements (1950–52).



Ernst Weber

Irven Travis (M '46), Director of Research, Burroughs Adding Machine Company, Philadelphia, Pa., has been elected Vice-President in Charge of Research. Dr. Travis was graduated from Drexel Institute of Technology in 1926, with a bachelor of science degree in electrical engineering. At the University of Pennsylvania, Philadelphia, he received a master of science degree in electrical engineering in 1928, and a degree of doctor of science in 1938. He was a member of the faculty at the University from 1928 until 1949 when he became associated with the Burroughs Adding Machine Company. He became a Director of the company in 1951. For 5 years, from 1941 to 1946, Dr. Travis was on leave of absence from the University of Pennsylvania, serving in the United States Navy. In 1945, he went to Japan with the Naval Technical Mission as chief investigator of Japanese Fire Control. He is currently serving the AIEE on the Electronics and Computing Devices Committees.

A. C. Abbott (M '46), manager, Commercial and Distribution Department, Shawinigan Water and Power Company, Montreal, Quebec, Canada, has been appointed Vice-President of Distribution. Mr. Abbott received a degree in electrical engineering from McGill University in 1926, after which he joined the Shawinigan Water and Power Company. After holding various positions

in the company he was appointed electrical engineer of the Commercial and Distribution Department in 1938. In 1947 he was made assistant manager, and in 1950 manager of the department.

W. E. Miller (AM '40, M '45), steel mill section, industrial engineering divisions, General Electric Company, Schenectady, N. Y., has been appointed manager of the steel mill section. Mr. Miller was graduated from the University of California, in 1939, with a bachelor of science degree in electrical engineering. He became associated with the company shortly after his graduation. Mr. Miller is a member of the Association of Iron and Steel Engineers, and has served the AIEE on the Mining and Metal Industries Committee since 1947.

Zay Jeffries (M '36, F '42), retired, General Electric Company, Pittsfield, Mass., has been appointed a member of the Committee on Materials of the Department of Defense Research and Development Board. Dr. Jeffries is a former Vice-President of the General Electric Company, and was recently named a Vice-Chairman of the Minerals and Metals Advisory Board of the National Academy of Sciences. He served the Institute on the Edison Medal Committee (1945–50).

G. H. Mandeville (M '45), chief engineer, United States Navy Engineering Office, Seattle, Wash., has been made manager of the newly established west coast office of the Leo A. Daly Company, Omaha, Neb.

A. A. Nims (AM '11, M '28, Member for Life), professor and Chairman of the Electrical Engineering Department, Newark (N. J.) College of Engineering has retired. Mr. Nims was graduated from Worcester Polytechnic Institute in 1908 with a bachelor of science degree in electrical engineering. From 1911–12 he was associated with the Murphy Electricity Rectifier Company, Rochester, N. Y., as assistant in design and development. His next position was with the Crocker-Wheeler Company, Ampere, N. J., and from 1919–22 he was employed by the Siemumd-Wenzel Electric Welding Company, New York, N. Y. In 1922 Dr. Nims joined the faculty of the Newark College of Engineering where he became associate professor, professor, and then Chairman of the Department of Electrical Engineering. Mr. Nims is a member of the American Society for Engineering Education, Tau Beta Pi, and Sigma Xi.

D. A. Griffith (AM '39, M '49), assistant to general manager, Allis-Chalmers Manufacturing Company, Pittsburgh, Pa., and **D. K. Steidinger** (AM '41, M '48), sales engineer, Allis-Chalmers Manufacturing Company, Washington, D. C., have been named assistant managers of the company's Washington, D. C., district office. Mr. Griffith will be in charge of federal controls and regulations, and Mr. Steidinger will be in charge of sales. Mr. Griffith has been with the company since 1927, and Mr. Steidinger has been associated with Allis-Chalmers since 1940.

C. T. Shoch (M '48), manager, Industrial Sales Department, Pennsylvania Power and Light Company, Allentown, has been elected Vice-President of the National Society of Professional Engineers representing the northeastern area. **E. W. Seeger** (AM '16, F '36), Vice-President in charge of development and assistant secretary, Cutler-Hammer, Inc., Milwaukee, Wis., has been elected Vice-President of the National Society of Professional Engineers representing the central area. Mr. Seeger served the AIEE as Vice-President (1949–50), and on several Institute committees.

J. J. Howard (AM '46, M '48), Vice-President and general manager, California Electric Construction Company, Los Angeles, has been made manager of the Foothill Electric Corporation, Oakland, Calif. His previous experience includes association with the Watson Flagg Engineering Company, New York, N. Y., where he was superintendent and then project manager. He joined the California Electric Construction Company in 1948.

Wilfred Sykes (AM '09, F '14, Member for Life), Chairman, Executive Committee, Inland Steel Company, Chicago, Ill., was given a Missouri Honor Award for Distinguished Service in Engineering at the second annual Engineers' Convocation at the University of Missouri, Columbia, on March 22, 1952. Mr. Sykes has been active in the AIEE having served on the following committees: Edison Medal (1919–21); Marine (1915–20); and Mines (1913–16, Chairman 1913–16).

C. H. Mueller (AM '51), manager, Substation Department, Rumsey Electric Company, Philadelphia, Pa., has been elected a Vice-President of the company.

H. H. Sheppard (AM '34, M '51), manager, Philadelphia Office, and **R. R. Wylie** (M '46), manager, Meter Department, both of the Rumsey Electric Company, Philadelphia, Pa., have been appointed respectively to the positions of, manager, Transformer and Electrical Equipment Department, and manager, Electrical Metering Equipment Department.

G. R. Mezger (AM '37), technical sales manager, and **E. G. Nichols** (AM '47), assistant technical sales manager, Allen B. Du Mont Laboratories, Inc., Clifton, N. J., have been promoted to the positions of engineering manager and technical sales manager respectively. Mr. Mezger joined Du Mont in 1936 as a development engineer. He is a member of the Institute of Radio Engineers and has served on the AIEE Publication Committee (1951–52). Mr. Nichols has been with the company since 1947.

D. E. Craig (AM '45, M '49), sales manager, meter and instrument divisions, and **J. C. Garrett** (AM '42), assistant manager, Meter Sales Department, General Electric Company, Lynn, Mass., have been appointed to the positions of manager of General Electric's Somersworth, N. H., plant, and acting manager of marketing, Meter and Instrument Department, respectively. Mr. Craig joined General Electric in 1936 and Mr. Garrett has been associated with the company since 1935.

W. L. Everitt (AM '25, F '36), Dean, College of Engineering, University of Illinois, Urbana, has been appointed a member of the Divisional Committee for Mathematical, Physical, and Engineering Sciences of the National Science Foundation. Dr. Everitt is an active member of the AIEE. He served as a Director of the Institute (1947–51) and on the following committees: Communications; Technical Program; Education; Edison Medal; Research; and Executive.

E. E. Parker (M '49), engineering manager, turbine division, General Electric Company, Schenectady, N. Y., has been appointed manager of the Design Engineering Services Department, and acting manager of the Production Engineering Services Department. Mr. Parker has been with General Electric since 1931.

Henry Logan (AM '19, F '43), Vice-President in Charge of Research, Holophane Company, New York, N. Y., will deliver a paper before the British Illuminating Engineering Society Summer Meeting, Eastbourne, England. He is currently serving the AIEE on the Board of Examiners.

H. A. Winne (AM '16, F '45), Vice-President, General Electric Company, Schenectady, N. Y., has been appointed a member of the Committee of Atomic Energy, Research and Development Board, Department of Defense. Mr. Winne currently is serving the AIEE on the Edison Medal Committee.

H. S. Bennett (AM '42, M '45), Senior Partner, Bennett-Klayton Associates, Engineering Consultants, Wanamassa, N. J., has been appointed Director of Research and Engineering, engineering and production division, Dynamic Electronics-New York, Inc., New York, N. Y. He is a member of the Institute of Radio Engineers, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

R. N. McCollom (AM '47), central station supervisor, Westinghouse Electric Corporation, Detroit, Mich., has been appointed manager of the Application Engineering Department, at the company's plant in Sharon, Pa. Mr. McCollom has been on loan to the National Production Authority for the past year where he held the position of chief of the transformer and switchgear section of the electric equipment division.

F. J. Given (AM '28, M '48), transmission apparatus engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has been made director of apparatus and materials engineering, Sandia Corporation, Albuquerque, N. Mex.

M. G. Alderink (AM '50), distribution engineer, Cincinnati (Ohio) Gas and Electric Company, has been assigned as a sales representative to the Duluth, Minn., branch

office of Allis-Chalmers Manufacturing Company's general machinery division.

W. C. Stoker (M '45), professor of electrical engineering, Rensselaer Polytechnic Institute, Troy, N. Y., has been made Director of Rensselaer's computer laboratory.

B. T. Carmody (AM '45), electrical engineer, Construction Department, Swift and Company, Chicago, Ill., has been appointed sales engineer for the S & C Electric Company, Chicago.

A. J. Ward (AM '47), engineer, Electrical Department, Sargent and Lundy, Engineers, Chicago, Ill., has been named assistant sales manager of the S & C Electric Company, Chicago.

W. C. Bullock (AM '51), electrical engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named an engineer's assistant at the company plant at Pittsburgh, Pa.

J. B. Sullivan (AM '50), sales and application engineer, Pennsylvania Transformer Company, New York, N. Y., has been transferred to the sales office in Canonsburg, Pa., headquarters of the company. His new title is special application engineer.

D. E. Winslow, Jr. (AM '49), proposal engineer, Sales Department, Pennsylvania Transformer Company, Canonsburg, has been transferred to New York to replace Mr. Sullivan in the company's sales office there.

C. A. Edman (AM '38), engineer, General Electric Company, Bridgeport, Conn., has been named manager of advance engineering.

J. M. Moran (AM '41, M '45), Head Electrical Department, Barkley and Dexter Laboratories, Inc., Boston, Mass., has been appointed Vice-President of the company.

OBITUARY • • • •

Louis Gerard Pacent (M '18, F '30), President and Technical Director, Pacent Engineering Corporation, New York, N. Y., died on April 7, 1952. He was born in New York City on June 23, 1890, and attended Pratt Institute where he studied electrical engineering with special study in electrical communication. In 1919 he founded the Pacent Electric Company for the purpose of manufacturing radio equipment and electric devices. Seven years later he founded the Pacent Corporation and in 1928 the Pacent Reproducer Corporation was begun. During the early part of his career Mr. Pacent worked very closely with Guglielmo Marconi. He developed various sound devices which the Army and Navy used during World War I, and in 1946 he received the War Department's Certificate of Appreciation in recognition of his engineering services to the Signal Corps. In 1951 he was awarded the Marconi Memorial Medal of Achievement for his pioneer work in radio and communication. Mr. Pacent was President of the Radio Club of America and was a member of the Institute of Radio Engineers, the Society of Motion Picture and Television Engineers, and the Acoustical Society of America. He served on the AIEE Communications Committee (1939–49) and on the Board of Examiners (1946–52).

Albert Milmow (M '30), sales engineer, Charlotte, N. C., died on March 12, 1952. He was born in London, England, on November 14, 1877. He came to this country at an early age, and in 1894 he was employed by the General Electric Company. In 1899 Mr. Milmow went to South America and later to the Philippine Islands and China where he was engaged in designing and supervising lighting plants. He returned to this country in 1905 and was subsequently associated with several different companies. Since 1922 he had been an independent representative of various electrical manufacturing companies. He was past president of the North Carolina Society of Engineers.

Alfred W. Ainsworth (AM '28), President, William Ainsworth and Sons, Inc., Denver, Colo., died on February 21, 1952. He was born on October 30, 1884, in Denver. He had been associated with the Pennsylvania Railroad, the General Electric Company, and the Denver Tramway. However, during most of his career he had been associated with William Ainsworth and Sons, Inc., a company founded by his father in 1880, which manufactures precision instruments. Mr. Ainsworth was chairman of the Denver Section of the AIEE (1933–34), and was also a member of the Colorado Society of Engineers.

Louis F. Rodewig (M '50), assistant district manager, industrial division, General Electric Company, New York, N. Y., died on February 7, 1952. He was born in Bellaire, Ohio, on October 27, 1900, and was graduated from the Case Institute of Technology in 1922 with a bachelor of science degree. Following his graduation, Mr. Rodewig joined General Electric and 3 years later was assigned to the New York Sales District. In 1948 he was named head of the machinery manufacturers sales section, and in 1950 was promoted to the position of assistant industrial manager.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of April 17, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Saunders, L., owner, L. Saunders Electrical Machinery, Norfolk, Va.

1 to grade of Fellow

To Grade of Member

Aitchison, T. C., engg. planning supervisor, General Electric Co., Pittsfield, Mass.
Alleman, J. J., electrical engineer, Mathieson Chemical Corp., Lake Charles, La.
Ashenden, H. B., division engineer, Allis-Chalmers Mfg. Co., Boston, Mass.
Blades, J. M., cable engineer, Hydro-Electric Power Comm., Toronto, Ont., Can.
Bovier, R. F., chief engr., Northern Pennsylvania Power Co., Towanda, Pa.
Brown, W. E., electrical supervisor, Gussow & Skidmore, New York, N. Y.
Buckeridge, R. M., electrical engr., Goodman Mfg. Co., Chicago, Ill.
Bull, I. S., Jr., engr., J. P. Stevens & Co., Inc., Greenville, S. C.
Burnham, R. F., electric distribution supt., The Connecticut Power Co., Stamford, Conn.
Cham, E. J., design engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Christen, V. F., design engr., Moloney Electric Co., St. Louis, Mo.
Christie, A. B., elec. engr., Southern California Edison Co., Los Angeles, Calif.
Clark, N. R., mgr., small capacitor engg., General Electric Co., Hudson Falls, N. Y.
Connon, W. D., plant engr., Bell Telephone Co. of Pennsylvania, Philadelphia, Pa.
Cook, J. H., project engr., Laboratory for Electronics, Inc., Boston, Mass.
Cooper, C. C., service shop supt., General Electric Co., Portland, Oreg.
Corporon, E. K., vice-pres.–secy., Interchange Power Services, Inc., Des Moines, Iowa
Crafton, W. L., supt., meter dept., Arkansas-Missouri Power Co., Blytheville, Ark.
Danser, J. W., engr., American Tel. & Tel. Co., New York, N. Y.
DeCroce, G., consulting & application engg. supervisor, Westinghouse Electric Corp., Pittsburgh, Pa.
Delagrange, C. R., spinning engr., Celanese Corp. of America, Narrows, Va.
deLeva, M. M., independent consulting engr., 29, Via Pastrengo, Torino, Italy
Dye, R. H., engr., General Electric Co., Schenectady, N. Y.
Fahrnkopf, C. D., electrical engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Gerlach, F. H., chief engr., Fasco Industries, Inc., Rochester, N. Y.
Gragg, C. W., transmission engr., Southwestern Public Service Co., Amarillo, Tex.
Halberstadt, R. L., senior staff engr., The Bell Telephone Co. of Pennsylvania, Philadelphia, Pa.
Hanna, R. C., mgr., FHP motor dept., General Electric Co., Fort Wayne, Ind.
Hatfield, D. W., field engr., National Electric Coil Co., Columbus, Ohio
Hemmenway, D. L., assoc. editor, *Electric Light and Power*, Chicago, Ill.
Hills, W. B., line engr., General Electric Co., Schenectady, N. Y.
Holt, W. A., production mgr., Arnold O. Beckman, Inc., South Pasadena, Calif.
Hull, F. M., supervisor cable engr., The Detroit Edison Co., Detroit, Mich.
Hutton, E. W., section engr., General Electric Co., Schenectady, N. Y.
Mahan, H. E., mgr., illuminating lab., General Electric Co., Lynn, Mass.
Mellor, A. G., application engr., General Electric Co., Schenectady, N. Y.
Mengel, P. F., district supt., Niagara Mohawk Power Corp., Potsdam, N. Y.
Millar, N. P., development engr., General Electric Co., Lynn, Mass.
Miller, L. M., electrical engr., Eastman Kodak Co., Rochester, N. Y.
Murchison, H. E., sales engr., Simplex Wire & Cable Co., Cleveland, Ohio
Murdoch, J. E., chief engr., eastern area, The Bell Telephone Co. of Pennsylvania, Philadelphia, Pa.
Olive, W. W., Jr., design & test engr., James R. Kearney Corp., St. Louis, Mo.
Otte, G. W., application engr., General Electric Co., Schenectady, N. Y.
Peterson, J., designing engr., General Electric Co., Lynn, Mass.
Pickering, L. J., electrical supt., Koppers Co., Inc., Dearborn, Mich.
Price, S., engr., Headman, Ferguson & Carollo, Phoenix, Ariz.
Rice, M. E., emeritus assoc. prof. of physics, University of Kansas, Lawrence, Kans.
Rietz, E. B., div. engr., General Electric Co., Philadelphia, Pa.
Robertson, T. C., asst. to electrical supt., International Nickel Co., Copper Cliff, Ont., Can.
Schiek, W. H., managing engr., General Electric Co., Philadelphia, Pa.
Schleif, F. R., electrical engr., Bureau of Reclamation, DFC, Denver, Colo.
Schwartzburg, W. E., asst. engr., switchgear sec., Allis-Chalmers Mfg. Co., West Allis, Wis.
Sibley, H. C., Jr., electronic engr., General Railway Signal Co., Rochester, N. Y.
Southwell, J. D., city electrician, Central Fire Station, Beaumont, Tex.
Stimson, A. G., photometric engr., General Electric Co., Lynn, Mass.
Stomski, W. J., asst. engr., A & OS divs., General Electric Co., Schenectady, N. Y.
Tarn, L. W., staff engr., Bell Telephone Co. of Pennsylvania, Pittsburgh, Pa.
Wilkinson, R. W., district plant engr., The Bell Telephone Co. of Pennsylvania, Norristown, Pa.
Williams, R. O., district engr., Southern Bell Tel. & Tel. Co., Shreveport, La.

59 to grade of Member

Free-Floating Automatic Weather Station Reports Data by Radio

A free-floating buoy-type weather station, developed by the National Bureau of Standards (NBS) for the Navy Bureau of Ships during World War II, reports weather data by radio automatically and unattended. The NBS buoy automatic weather station consists essentially of a timing mechanism, several weather-responsive devices, a relaxation or keying oscillator, and a simple 2-stage radio transmitter. The weather-responsive devices cause associated resistors to vary with changes in weather conditions. At 3-hour intervals the timing mechanism, a modified automobile-type electric clock, turns the station on. While a program selector switch inserts one weather resistor after another into the keying oscillator circuit in predetermined sequence, a relay in the plate circuit of the keying oscillator switches the transmitter on and off at a rate proportional to the value of the particular resistor.

Twenty-seven feet in over-all length and weighing 280 pounds, the station centers mechanically around a buoy cylinder 5 feet long and $16^1/_2$ inches in diameter. Fastened to the bottom of the cylinder is an 8-foot tail pipe ending in 40 pounds of lead ballast. On top of the buoy cylinder is a 7-foot superstructure above which an antenna extends another 7 feet. At the junction of the antenna and the superstructure is an antenna tuning house, while an anemometer is supported at the top of the antenna. Housed in the buoy cylinder are the rest of the electronic components and weather-responsive elements, as well as the batteries.

Each transmission lasts about 10 minutes. First comes an attention signal, consisting of a series of rapid pulses easily recognizable by the listening station operator. Transmitted next is a reference signal; this will be of constant pulse rate in the absence of transmitter damage or aging, and any variation in pulse rate indicates a need for calibration corrections of the other signals. An identification signal follows, the rate of which is characteristic of the particular weather station. All of these signals result from switching appropriate resistors into the relaxation oscillator circuit. The various meteorological signals are next transmitted. With completion of the program, the selector switch disconnects all elements and turns off the transmitter. The clock mechanism, however, continues to run and at the proper time starts the sequence again.

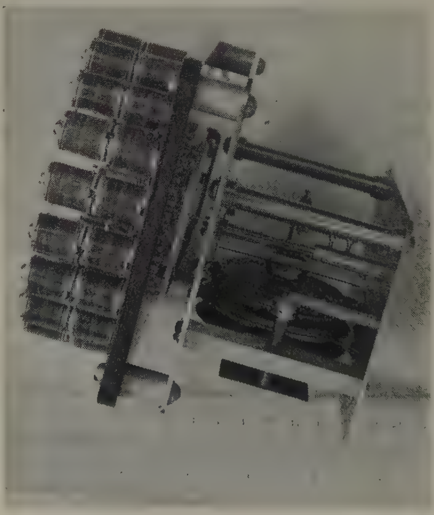
Five meteorological variables are reported by the standard model of the weather station: air and water temperature, air pressure, and wind speed and direction. Five different devices, in combination with the relaxation oscillator, key the transmitter at rates corresponding to each of these variables.

The air-temperature and water-temperature elements each consist of a temperature-responsive ceramic resistor. Mounted inside the buoy cylinder, the water-temperature element attains the temperature of the water because of conduction through the cylinder walls. The air-temperature element, at the bottom of the antenna tuning house, is protected by a louvered shield.

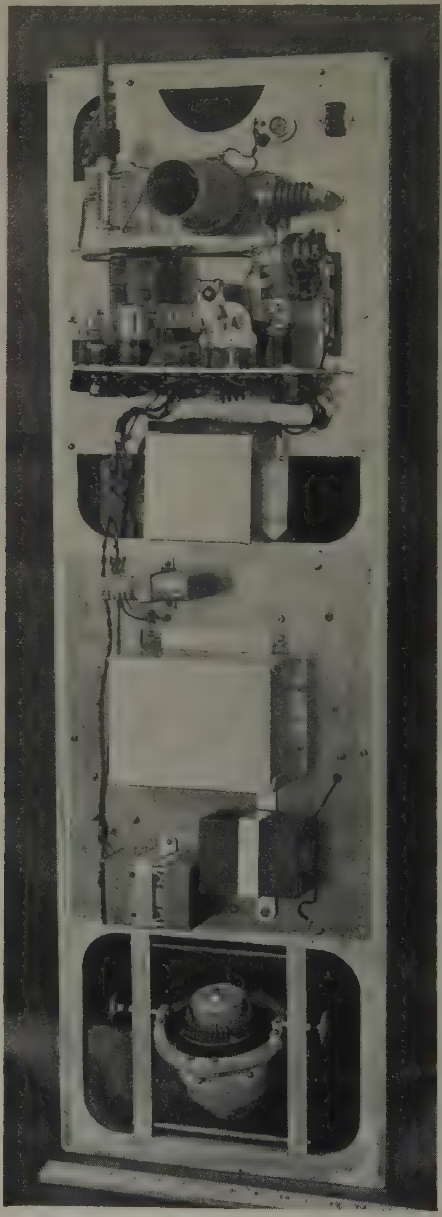
The barometric unit, of the aneroid type, is located inside the buoy cylinder. Prior to transmission of the pressure signal the indicating arm moves freely over, but not in contact with, 50 contacts connected to resistors. A barometer clamping magnet, energized during transmission of the pressure signal, holds the indicating arm against the contact over which it has located itself.

The air-speed indicating mechanism differs from the others in that no variation of resistance is involved. Instead, an electric contact is made with every revolution of the anemometer, and this contact keys the transmitter directly. By reference to the anemometer calibration, the transmitter pulse rate gives the air speed.

The wind direction indication from the free-floating buoy, initially a perplexing



The barometric unit of the weather station is of the aneroid type. With changes in pressure, a rotating arm moves past 50 electric contacts connected to resistors (above)



Main equipment panel of the weather station. The panel, which fits inside the buoy cylinder, carries the weather-responsive components, including the radio transmitter and keying oscillator (top) and compass for indicating wind direction (bottom)

The cylindrical buoy of the National Bureau of Standards' automatic weather station houses most of the electronic equipment; the superstructure (top) supports the wind vane, an antenna-tuning housing, the transmitting antenna, and the anemometer. An 8-foot tail pipe with 40 pounds of lead ballast (bottom) extends downward from the bottom of the cylinder

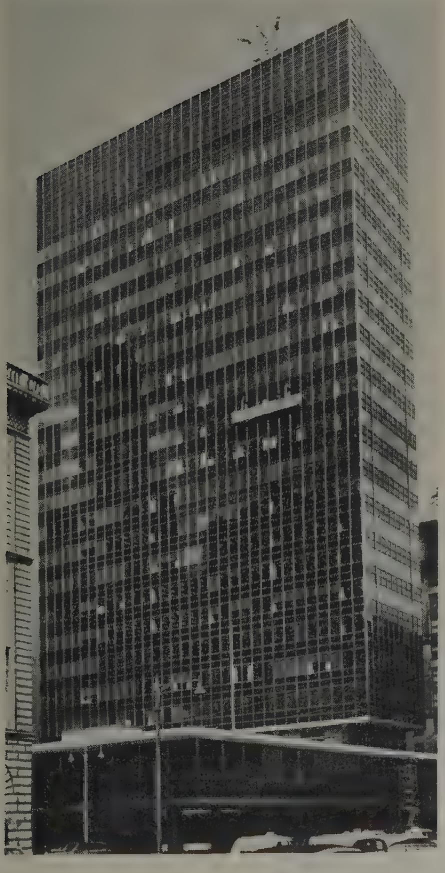
problem, was accomplished by letting the whole buoy serve as a highly damped weather vane. While a rudder on the buoy superstructure keeps the buoy oriented in the direction of the wind, a direction indication is given by a modified aircraft-type magnetic compass inside the buoy. Immediately above the master compass needle, which is sealed in liquid, a slave needle rotates over 36 resistor-connected contacts mounted at 10-degree intervals. During transmission of wind direction, a clamping solenoid holds the slave needle against the contact toward which it is pointed.

A combination of two special devices permits the inside of the buoy to attain atmospheric pressure, yet prevents water from entering. A solenoid-actuated valve located in the antenna tuning house is energized during the entire transmission period, so that air pressure inside the buoy equals that outside when the pressure signal is transmitted. An electrode supported by an insulator is arranged so that, if the tuning house becomes submerged or swamped, the conductivity of the sea water short-circuits the air-valve solenoid. This short circuit closes the air valve before water enters the buoy, and keeps it closed until the water subsides.

A special watertight magnetic coupling, which transmits anemometer rotation to the contact mechanism inside the buoy, solved another design problem. This coupling, at the bottom of the anemometer shaft, consists of a permanent magnet driving a slave magnet on the other side of a watertight bulkhead. The slave magnet operates the keying mechanism.

Scaffold-Elevator Installed for Exterior Maintenance of New York Skyscraper

Safety and economy are the keynotes of the specially designed, all-steel, window-washing and exterior maintenance machine recently placed in operation at Lever House, headquarters of Lever Brothers Company, New York, N. Y. The 24-story office building has 1,404 fixed, nonopening windows nearly flush with the exterior with only 1 inch of sill. It is estimated that $100,000 have been saved in building costs alone by installing fixed instead of conventional windows. Costs of washing have been cut by two-thirds and substantial savings in interior cleaning, heating, and air conditioning will be achieved. Two men can clean the outside of all 1,404 windows in 6 days.



The specially designed window-washing and exterior maintenance machine for the Lever Brothers Company's new headquarters building in New York City features a roof-car installed inside the parapet of the building (see circled area) which allows a scaffold to travel up and down the sides of the building

Designed, constructed, and erected by the Otis Elevator Company, the device consists of a roof-car weighing about 11 tons which rides on 40-pound railroad tracks on the roof and a scaffold 28 feet long by $2^1/_2$ feet wide which travels up and down three sides of the building.

A miniature railroad, complete with two switches, installed on the roof inside the parapet of the building, supports the roof-car and permits workers on the washing and maintenance platform to reach six windows at a time. The roof-car rides on three wheels, one without power mounted on the rear of the car, and the other two mounted on the front, both powered by 1-horsepower motors through reduction gearing which permits a horizontal speed of 25 feet per minute.

Power for raising and lowering the maintenance scaffold is provided by a $7^1/_2$-horsepower squirrel-cage motor, mounted on the roof-car, which drives a 48-inch-diameter cable drum through reduction gears.

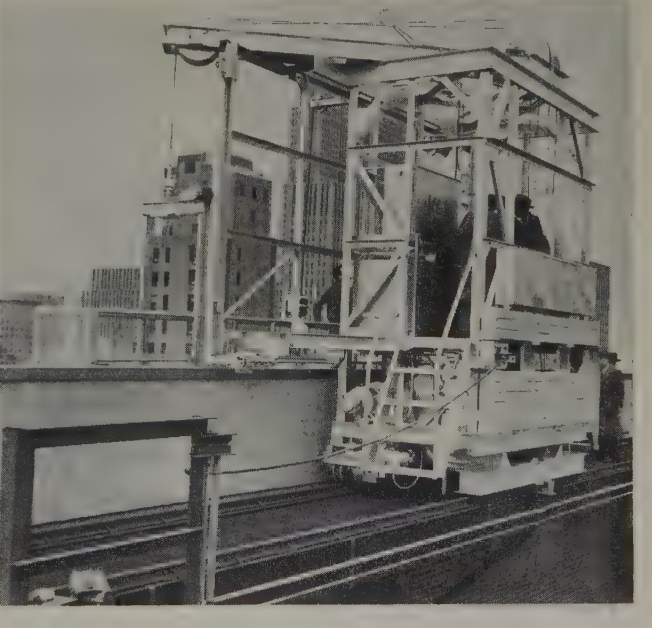
Six conveniently located electrical outlets furnish 208-volt 3-phase 60-cycle current from the building system through flexible cable mounted on a spring-loaded reel on the roof-car.

Horizontal movement of the car is controlled by a constant-pressure push button mounted on the car. Safety interlocks prevent movement of the car when the scaffold is lowered over the side. The roof-car can be moved only when the scaffold has been raised completely and has been cranked into position against the car itself. Safety dogs on the rails and limit switches prevent the car from overriding the ends of the rails.

Vertical movement of the scaffold itself is controlled by constant-pressure push buttons on the scaffold, although, in an emergency, it can be controlled by push buttons on the roof-car. Interlocks prevent movement of the scaffold while the roof-car is in motion or when the scaffold is not in the precise horizontal position to engage the stainless steel, T-shaped, vertical guide-rails fixed to the sides of the building. When the shoe on the scaffold engages one of the guide-rails, the platform can be lowered and raised at a speed of 35 feet per minute. Limit switches at the third floor and top of travel prevent overriding the guide-rails.

The scaffold is equipped with spring-backed canvas-covered rollers at the top and bottom of each end of the platform to assist the guide-rails in preventing undesirable motion and to keep the scaffold from scraping against the building. Control wires from platform to car are carried on a spring-loaded reel on the roof-car. A private telephone from the platform to the roof-car and to the building maintenance office provides emergency as well as regular communication.

The platform itself weighs 3,000 pounds



The roof-car is spotted in exact position so that shoe on the scaffold engages the vertical guide rail on the building exterior and the scaffold is ready to be lowered

Future Meetings of Other Societies

American Electroplaters' Society. 39th Annual Convention. June 16–20, 1952, Conrad Hilton Hotel, Chicago, Ill.

American Society for Testing Materials. Annual Meeting. June 23–27, 1952, Hotel Statler, New York, N. Y.

Conference on Industrial Research. Third Annual Conference. June 9–13, 1952, Columbia University, New York, N. Y.

Conference on Optical Methods in Industry. June 18–20, 1952, Institute of Optics, University of Rochester, Rochester, N. Y.

Edison Electric Institute. 20th Annual Convention. June 2–5, 1952, Cleveland, Ohio

International Organization for Standardization. Triennial Meeting. June 9–21, 1952, Columbia University, New York, N. Y.

National Association of Electrical Distributors. 44th Annual Convention. June 9–13, 1952, Atlantic City, N. J.

National Fire Protection Association. Annual Meeting. June 9–13, 1952, Hotel Statler, New York, N. Y.

National Society of Professional Engineers. Annual Meeting. June 5–7, 1952, Tulsa, Okla.

The American Society of Mechanical Engineers. Semiannual Meeting. June 15–19, 1952, Sheraton-Gibson Hotel, Cincinnati, Ohio

and is designed to carry a live load of 1,500 pounds. Ordinarily, only two men with window-cleaning equipment occupy the scaffold. Four galvanized 3/8-inch-diameter, 6×19 steel wire hoisting ropes, with a breaking strength of 9,000 pounds each, support the scaffold, two at each end. The ropes are equalized and provide a safety factor of eight.

The cycle of operation starts with the exact positioning of the car at a marked point on the track. The platform is then swung out and lowered so that the shoe on the scaffold engages the vertical guide-rail. The window washers lower the platform floor by floor, cleaning six windows per floor until the lower limit is reached. The platform then is raised completely to the top, swung in against the roof-car which is moved to the next position, and the cycle is repeated. The power cable is changed from outlet to outlet as the car moves around the top of the building.

All possible safety devices have been provided and the scaffold is completely enclosed: on the three outer sides by 3-foot-high guard-rails with steel mesh grille and on the side next to the building by a guard-rail without the grille.

When not in use, the roof-car, with the scaffold secured in position against it, is parked in the center of the roof on rails connected by switches to the "main line."

Navy Testing Underwater Sound Signals for Use in Rescue Work

The United States Navy has acquired basic patent rights to SOFAR (sound fixing and ranging), a development which allows underwater sounds to be picked up more than 3,000 miles away. The Navy Bureau of Ships said that SOFAR may be adopted for search and rescue operations. Tests under way in the Pacific to evaluate it will be completed soon.

If SOFAR is adopted for search and rescue work, life rafts and aircraft will be equipped with small bombs. Dropped overboard, these bombs will sink to proper water depths and explode. Sound waves thus released will be picked up by Navy SOFAR stations and positions of craft will be determined by triangulation.

Possibility of adapting SOFAR to search and rescue operations came as the result of research done by Dr. Maurice Ewing of Columbia University. While working on submarine-detecting methods under a Navy contract at the Woods Hole, Mass., Oceanographic Institution, Dr. Ewing developed the principles and equipment used in SOFAR.

He found that there is a natural sound channel deep in the ocean which may be used for transmitting audible signals over great distances. Center of this sound channel is roughly 4,200 feet below the surface of the Atlantic and somewhat higher in the Pacific. It is established by a combination of temperature and water-pressure factors.

Sound waves bend toward the region where they have the lowest velocity. Velocity of sound waves under water is affected by both temperature and pressure. Higher temperatures, as well as higher pressures, increase velocity. At depths above 4,200 feet in the Atlantic, the temperature factor is dominant. Sound waves in that area bend downward toward the lower temperatures where they will travel more slowly. At depths below 4,200 feet the pressure factor is dominant and sound waves at those depths bend upward.

Thus, at 4,200 feet the pressure and temperature factors create a region of minimum sound velocity. A large part of any sound originating at this depth is, therefore, carried along this channel for great distances without hitting the ocean surface or bottom. It thus avoids high losses due to reflection, absorption, and scattering.

Among the important features of the discovery is that sound signals on this channel can be distinguished from various other sounds which may occur in the ocean.

Portable Field Telephone Set Designed to Fit Military Needs

A new and improved portable field telephone set has been developed by Bell Telephone Laboratories, Inc., New York, N. Y., to meet the forward-looking program of the Signal Corps of the United States Army.

The new field set, the first since the *EE-8* used in World War II and Korea, is designed to meet the performance requirements of the Signal Corps Engineering Laboratories and incorporates a number of special military features.

It is light in weight, about 8 pounds compared to the 11 pounds of the present set, due to lightweight components and the use of lightweight magnesium in the container. It is small, about the size of a loaf of bread. Tough new plastics are used for the handset, and the entire set is expected to survive parachute drops with ease. It is very flexible; different circuit arrangements are available, common battery, local battery, or a combination of these.

In an emergency the set operates efficiently for several miles without batteries, on voice power alone. The handset is shaved at the ear-piece end so it can fit beneath a battle helmet with comfort. It works effectively at 40 degrees below zero or in the heat of 130 degrees, and at altitudes over 10,000 feet.

It can be immersed in water without effect; the entire set is waterproofed by a series of gasket seals. A soldier wearing long, heavy Arctic mitts can operate the set.

The signal "bell," actually a sharp tapping sound such as a woodpecker makes, can be adjusted in loudness from complete silence, through a whisper, to a loud penetrating alarm.

The woodpecker calling signal is pitched at a frequency which has been found best for hearing in the presence of background noise, and one which humans can hear best even when their hearing has been dulled by combat fatigue. The possibility of reducing the signal to a whisper or even silencing it completely is desirable for outposts in exposed positions.

The circuitry of the new set is basically the same as that of the new Bell System 500-set, with a powerful transmitter and an automatic equalizer to adjust this power to varying requirements; an extra sensitive receiver, also controlled by the equalizer, with built-in protection against clicks from power surges.

The new set retains a special arrangement of the older set which was designed specifically for use under extreme field conditions, in this case, in very cold temperatures. On local battery operation, the set gets its power from a pair of ordinary flashlight batteries which are enclosed in the container. In very cold weather, however, such batteries become so sluggish they do not provide enough power. In the new set, arrangements are made for wiring the set to a pair of batteries which the soldier can carry in his pocket, next to his body, where it is warm enough to ensure efficient operation.

Two problems were posed by military requirements; that the set be entirely waterproof, and that it be transportable at altitudes as high as 50,000 feet. The first could be easily met by completely sealing the set with gaskets; but then, at 50,000 feet, there would be normal air pressure inside the set but very little air pressure on the outside, an imbalance that might cause serious mechanical distortion or even breakage. The difficulty was solved by inserting tiny ceramic valves in the set and in the handle of the handset. The ceramic, about the size of the head of a carpet tack, allows air to pass through so that air pressures inside and outside the set are the same at any altitude, and yet it keeps water from entering.

Military Equipment Rust-Guarded by New Electronic Device

A new electronic development that makes possible a more accurate means of safeguarding packaged military equipment from rust and corrosion during long storage periods was announced recently by Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.

The device is a small relative humidity indicator that is sealed inside of vaporproof containers with stored equipment and acts as a sentinel to warn of excessive humidity. It was developed in co-operation with the Department of Defense and tested under direction of the Ordnance Corps.

The moisture content of the sealed package

at any given time can be determined easily and quickly by plugging a small specially designed portable electron meter into an outside connection, and reading directly from it. The task of insuring that relative humidity in such packages does not exceed the critical point is a major problem for all branches of the Armed Services that have to store costly and delicate items of equipment.

Present methods of checking this humidity are not too reliable, and sample packages must be opened periodically and the contents inspected. Even if no signs of corrosion exist, the contents must be cleaned and resealed according to original specifications. This is a costly procedure; furthermore, since only sample packages are opened, there is no assurance as to the condition of all packages.

The new electronic humidometer is expected to overcome these problems. It is capable of detecting changes in relative humidity as small as 0.01 per cent.

Heart of the system is a tiny sensing element, about the size of a matchbook cover. It is made of plastic and embossed on one side with a gold leaf grid. This grid is coated with a hygroscopic film that changes in conductivity with changes in relative humidity. The element is so sensitive it can measure the presence of one-half a tablespoon of water in an average size living room of 12 × 18 feet.

When installed in packages, the sensing element is connected to an external plug by electrical leads that extend out through a vapor barrier. The amount of moisture in the package is shown on the specially designed meter, which is attached to the external connection when a reading is desired.

Low-Pressure Laminates Withstand Great Heat Intensity

Low-pressure laminates with a high degree of heat stability have been developed by Dow Corning Corporation, Midland, Mich. Molded of glass cloth and Dow Corning *2104* Silicone Bonding Resin at pressures from 3 to 30 per square inch, they will withstand continuous exposure to temperatures in the range of 500 degrees Fahrenheit and intermittent exposure to as high as 900 degrees Fahrenheit.

Physical and electrical properties of these materials are comparable to those of conventional high-pressure silicone-glass laminates molded at 1,000 pounds per square inch or higher. Their mechanical strength is superior to silicone-bonded moldings of chopped glass, mica, asbestos, or other inorganic fillers.

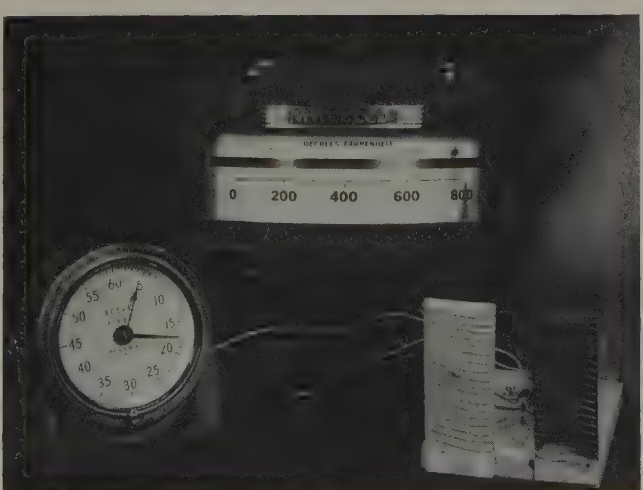
Finished laminates weigh less than aluminum or magnesium and are stronger than either at 500 degrees Fahrenheit. Smooth, nonporous, and easily machined, they are water repellent and resistant to most commonly used chemicals. Laminating stocks may be preformed and used to prepare complex shapes either by bag molding or in light metal molds. Flat sections can be laminated in thicknesses ranging from 0.01 to 2.00 inches.

Low-pressure lamination is a comparatively recent innovation in molding technique. With it, large and complex parts can be produced with a relatively small equipment cost. Its development stems from the wartime introduction of organic bonding resins which had sufficient initial "flow" to permit the escape of air bubbles and which, at the same time, could change rapidly from a liquid to a gel, all without the use of high pressure.

However, these organic resins are useful only at operating temperatures below 350 degrees Fahrenheit. For service at higher temperatures, low-pressure silicone-glass laminates were developed by Dow Corning.

Press time for low-pressure silicone-glass laminates is only 15 minutes for an 1/8-inch section. However, maximum heat stability calls for an afterbake of from 100 to 170 hours at 500 degrees Fahrenheit. In many applications, of course, high ambient temperatures may effect this afterbake during actual use, eliminating most of the oven-curing time.

Most of the product development work on these materials is taking place in the aircraft industry. Test laminates are already under evaluation for possible use as radomes, air ducts, tubing, instrument protectors, and guided missile noses. Their combination of properties also recommends them as covers for de-icing elements on wing and stabilizer tips and on the leading and trailing edges of helicopter blades.



To demonstrate the relative heat stability of low-pressure glass-reinforced laminates bonded with conventional organic resin and with silicone resin, sample sections of each were wound with a resistance wire connected through a variable transformer. A thermocouple was attached to the silicone-glass section. In less than 5 minutes at temperatures approaching 800 degrees Fahrenheit, the organic resin was charred and smoking, while the silicone remained unchanged. After 15 minutes the organic resin burned away almost entirely; the silicone was still unchanged

Ultrasonics Used to Salvage Metals Vital to Defense Effort

Ultrasonics are now being used at Raytheon Manufacturing Company, Waltham, Mass., to conserve materials vital to the nation's defense program. Tungsten, high on the list of critical materials, is among those alloys being salvaged by means of a new device. This device, vibrating at a frequency more than three times that of the highest audible pitch, literally shakes glass beads off tungsten rods salvaged from vacuum tubes which have proved faulty during manufacture and which require reprocessing. The new device permits the removal of glass sealed to the tungsten rods ten times faster than was possible by previously used methods.

The ultrasonic vibrator, oscillating at a rate of 27,000 times per second, sets up a kindred oscillation in the tungsten rod, which throws off the glass like a dog shaking off water. This effect is accomplished by compressional wave energy and utilizes the same principle that makes it possible for a singer's high note to shatter a wine glass.

The ultrasonic method is in contrast to the manual hammering process used during World War II, which not only was slower but also caused a greater percentage of the tungsten to be cracked and rendered unfit for further use. The new tool can do the work of approximately ten or more people operating under the old method, with a manifold increase in good, usable metal.

Other glass-sealing alloys such as molybdenum, platinum, kovar, and rodar also can be salvaged by this method. Most of these alloys also contain cobalt or nickel, both critical materials. The method can be applied to salvaging a variety of tubes, including those used in X rays, Geiger counter, radio and television equipment, and others employing hermetically sealed components.

Universal Testing Machine To Be Built at Lehigh University

The world's largest vertical universal testing machine is to be installed in a new building on the Lehigh University campus, at Bethlehem, Pa. Total cost of new equipment and building to be ready for the opening of the academic year starting September 1954, is estimated at $1,200,000. The new installation will be made in co-operation with Bethlehem Steel Company.

The new building will house a 5,000,000-pound capacity hydraulic tension-compression machine to be constructed at an estimated cost of $400,000, accessory equipment valued at $300,000, and modern laboratories which will widen the scope of testing in every field.

Primary responsibility for the design and supervision of the construction and installation of the machine will be shared by representatives of the Bethlehem Steel Company, representatives of the Baldwin-Lima-Hamilson Corporation, Philadelphia, and Professor William J. Eney, Head, Department of Civil Engineering and Mechanics and Director of the Fritz Engineering Laboratory at Lehigh University.

The 5,000,000-pound capacity machine, serviced by a 20-ton crane, together with auxiliary apparatus, will make possible a vast expansion in the services heretofore

University of Illinois network analyzer shown as installed in a specially prepared room in the Electrical Engineering Building. The units in the center of the board represent a portion of the generating stations with equivalent lines and loads grouped along two main plug panels

offered industry of the East coast in proof testing their products.

Tests which engineers are expected to bring to the laboratory from industry will include all kinds of materials including concrete cylinders and blocks, aluminum and magnesium castings, fabricated steel, oil-well shafts, wood, and wire rope.

An important detail will be the special anchoring floor and lateral supports for tests on large units which will not fit into the machine or require load application such as those which occur during windstorms, explosions, and earthquakes. This will also make it possible to apply additional vertical or lateral loads to plate girders when tested in the 5,000,000-pound machine.

Auxiliary machines, in small laboratories to be provided, will permit extensive studies on the effect of repeated and dynamic loads which often cause failure through the fatigue of the material. The laboratory now has a torsion machine of 2,000,000-inch-pound capacity which is in current use in developing information for the structural engineer. The scope of these studies will be extended when new fatigue torsion machines are added to the new laboratory center.

A platform, measuring 30 feet in width by 100 feet in length, will make possible for the first time full-size tests on plate girders of 100-foot span and unlimited height. Heretofore, engineers have had to base their design on tests made on much smaller girders.

The machine, with a height of approximately 53 feet above the floor level, will permit the testing of building columns and the compression members of railroad and building trusses. Tests then can be made on members 36 feet long and of a cross section used in these structures.

Structural tension members 36 feet in length, such as the suspension bridge cables and those in large railroad bridges, can be tested also.

The accessory equipment will include many features to insure good testing facilities. A device known as the automatic load maintainer will permit the 5,000,000-pound force to act continuously on a structure as it deflects and fails, eliminating manual control

New Bottling Plant Machine Uncases, Washes, and Loads

A new and adaptable bottling plant machine that will speed the uncasing and washing of milk bottles was demonstrated recently by the RCA Victor Division of the Radio Corporation of America at the Borden Company's Hamilton Park plant, Chicago, Ill.

The new device automatically removes milk bottles from the cases and feeds them to a large washer in the modern dairy. It is capable of feeding at rates of up to 576 bottles a minute. The machine, to be known as the RCA Full-Depth Uncaser and Washer-Loader, eliminates one of the last steps in the bottling cycle now performed by laborious manual methods.

The machine can be made to handle wooden, metal, or cardboard cases, or cartons, and a wide range of types and sizes of bottles. The cases are fed from the plant case-conveyor directly into the uncaser. Entering the lower portion of the machine, they are carried upward and inverted, with the bottles held in place.

As the cases continue through the machine, they reach points at which first the inner rows of bottles and then the outer rows are lowered into large, revolving transfer wheels with pliable rubber-gripping surfaces. The surfaces of the first wheels firmly grip the bottles in the center rows as they are released, and those in the second set of wheels grip bottles in the outer rows. As they revolve, the two wheels deposit the bottles on conveyor belts which deliver them to the washer-loader. Meanwhile, the cases are set right-side-up and delivered to a conveyor or to the right or left or to the rear of the machine. In the washer-loader machine, the bottles are spread to the full width of the automatic washing equipment, and then are guided into as many channels as required by the washer.

The new machine will automatically stop and ring a signal bell if faulty cases or improperly positioned bottles are fed in. The machine incorporates a bottle-supply control which automatically keeps an adequate supply of bottles ready to enter the washer.

University of Illinois Builds 10,000-Cycle Network Analyzer

The Department of Electrical Engineering, University of Illinois, Urbana, has completed the construction of its new 10,000-cycle network analyzer. It consists of 20 generator units, 152 pi line units, 56 load units, 34 autotransformers, 28 capacitor units, 24 mutual transformers, 20 generator reactances, 56 load voltmeters, and 16 special metering busses. There are 2 console metering desks which make it possible to study two separate problems simultaneously.

Special attention has been given to illumination of the board and to maximum ease and speed of operation and recording of data.

The University of Illinois analyzer is to be employed by a group of co-operating electrical companies and for research by the University.

C. L. Warwick Executive Secretary ASTM, Dies

C. L. Warwick, Executive Secretary of the American Society for Testing Materials (ASTM), and its administrative head since 1919, died on April 23, 1952. He was born on July 29, 1889. In 1909 he was graduated from the University of Pennsylvania with a degree in civil engineering. He was appointed Secretary-Treasurer of the ASTM in 1919, and in 1946 was made Executive Secretary. Mr. Warwick made many contributions to the field of standardization and research in materials and was recognized as an authority on materials. During World War II he was Head of the Specifications Branch of the Conservation Division of the War Production Board, and later served as Head of the Materials Division. He was the author of many technical articles and reports dealing with properties and tests of engineering materials. He was a member of Sigma Xi, the American Society of Civil Engineers, American Association for the Advancement of Science, and American Society for Metals.

ASTM to Celebrate Its 50th Anniversary in New York

The American Society for Testing Materials (ASTM) celebrates the 50th anniversary of its founding this year with a meeting on June 23–27, Hotel Statler, New York, N. Y. Also, the Tenth Exhibit of Testing Apparatus and Laboratory Supplies will take place at the same time.

Since its formal incorporation in the

Commonwealth of Pennsylvania, March 21, 1902, ASTM has concentrated its work on the promotion of knowledge of the materials of engineering and the standardization of specifications and the methods of testing.

In 1918, ASTM joined with the four engineering Founder societies to establish the present American Standards Association (ASA). It was formed to provide a means whereby standardizing organizations might co-ordinate their work and thus prevent duplication of effort.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Unity in the Engineering Profession

To the Editor:

Unity in the engineering profession is a cherished and long-sought goal much needed by society and by members of the engineering profession.

The recent recommendation of the Exploratory Group that the Engineers Joint Council be expanded to become the Unity Organization is a matter of great concern to us because it appears that there are two large groups going in opposite directions—each working to achieve what it calls "unity." It would seem that unity implies one organization rather than two. Mark states in the Bible: "If a house be divided against itself, that house cannot stand."

We are anxious to bring to the attention of other members of the profession the results of a survey conducted last December by the Interworks Committee of General Electric Engineers Associations (nonunion organizations in Schenectady, N. Y., Pittsfield, Mass., Lynn, Mass., Syracuse, N. Y., and Fort Wayne, Ind., with a total membership of approximately 3,300). This survey was conducted to determine the attitude of all General Electric engineers in these plants toward certain principles which the Co-ordinating Committee considers extremely important in the formation of the Unity Organization if it is to obtain the support of a majority of the profession. The results of this survey were sent to the Exploratory Group prior to its December 15, 1951, meeting and are listed as follows, together with the principles.

1. The Unity Organization should include all members of the engineering profession, regardless of technical specialty or affiliation with other societies.
2. The governing body should include representatives of all groups in the engineering profession; such as older and younger engineers, supervisory and nonsupervisory engineers, and so forth.
3. The governing body should be directly responsible to the individual members of the organization, rather than through other societies.
4. Within the bounds of practicability there should be the maximum of participation by the individual members at the local level in shaping policies.
5. Definite consideration should be given to the economic status of the engineer along with his professional status in the functioning of the Unity Organization.

	Per Cent Yes	Per Cent No	Per Cent Blank
1.	92	6	2
2.	92.5	6	1.5
3.	89	9	2
4.	95.5	3	1.5
5.	84.5	13	2.5

(4,130 ballots were distributed and 54 per cent were returned)

You will note that the plan recommended by the Exploratory Group does not agree with some of these principles.

Principle number 3 in particular seems to us to be fundamental and quite vital to the success of a Unity Organization. It is pertinent to recall that the Federated American Engineering Societies was formed in 1920 after much debate to decide whether it should be an organization of engineering societies or of individual engineers. The former plan was chosen and the organization did not last long. We do not know that this was the cause of its demise, but strongly suspect that it played an important part. Placing the control of the organization with the technical societies reminds us of the outmoded electoral college, the value of which has been questionable in recent years. We feel that this arrangement as we now understand it can scarcely encourage the interest and participation of individual engineers which will surely be needed for a successful and enduring organization. The great value and importance of the technical societies in their own fields is beyond question, but the Unity Organization should be controlled directly by its individual members.

In this connection, we commend the statement of Alex Van Praag, representative of the National Society of Professional Engineers in the Exploratory Group, who stated in his dissenting minority opinion: "The deliberations of the Exploratory Group over a period of more than 2 years have shown a majority of the members as preferring a Unity Organization based upon a democratic individual participation type of membership. This appears to be fundamental to a Unity Organization of a type that will long endure."

Principle number 2 seems important to us because we feel that a cross-sectional representation is necessary to represent all viewpoints adequately. The technical societies often lack representation of the viewpoint of nonsupervisory engineers and young engineers. On the other hand, union organizations lack representation of the viewpoint of supervisory engineers. What we need is a combination of all of these to fuse the new ideas and energy of young engineers with the valuable judgment and experience of the older engineers in a good middle course. We have faith in democratic procedures and in the good judgment of a balanced group. We feel that the problems and interests of all will be best represented by a Unity Organization whose governing body is truly representative of all groups in the profession.

Principle number 5 is one which is obviously controversial. We feel, however, that it must be faced squarely and realistically to reach some workable understanding and avoid widening the split already underway in the profession along union and nonunion lines. The organizations of other professions do consider and act on the economic problems of their members along with many other problems. J. Calvin Brown, former American Society of Mechanical Engineers president, has stated: "Some way ought to be found to increase the economic differential between engineering and the crafts. Engineering otherwise stands to lose some of the best minds to other callings." If economic problems are not adequately treated soon by a single organization (and this will require more than just "study" of the problem), there easily may be further growth of organizations utilizing collective bargaining with economic problems as essentially their only objective. (Note: We recognize that there are situations which, in the absence of a Unity Organization, have required that some engineers unionize.) However, such an alternative strikes us as being undesirable. It would mean the loss of certain privacy and freedom which we now enjoy as individuals, a decrease in salary spreads, a decrease in the incentives offered to individuals, and probably over-all, less competition and opportunity within the profession. It would cost society dearly in lost progress which would otherwise be realized with more incentives.

We believe that somehow the right and left wings of the profession must get together and reach a common solution. We believe that the afore-mentioned principles provide the basis for a middle-of-the-road organization whose effectiveness along both professional and economic lines will appeal to all engineers. This is a matter of real importance to all of us. We hope that if others agree with these principles, they will make their convictions known. We also believe that before any form of organization is definitely chosen, all individual members of the profession should be given an opportunity to express their choice among the various possibilities which have been considered.

J. C. DUTTON (M '48)
W. J. DEGNAN (M '50)
(Pittsfield General Electric Engineers Association, Pittsfield, Mass.)

To the Editor:

In the interests of real unity in the engineering profession, may I be allowed to submit the following thoughts for consideration.

I have been a member through all grades

and continuously since college, of one of our larger technical societies. I have also been a state section president and contributed to committees and publications. It should be evident then that I am not interested in sabotaging the value of our technical societies.

However, to many of us the crying need of engineers today is one paramount society that will truly represent all qualified engineers both professionally and technically at local, national, and international levels. It should be an integrated society, and not merely a banding together of existing socities into a federation which neither represents all qualified engineers nor permits direct and democratic election of officers and directors by the individual members.

Many of us in the grass roots are disappointed in the four unity plans (A, B, C, D) so far proposed and would like to see at least one other plan considered. We are also disappointed that the individual members have had little or no opportunity to study all plans, compromises, or worthy minority ideas.

Apparently the Exploratory Group in its report of December 1950 expected individual members to have ample opportunity to express their ideas on unity. This does not seem to have been done generally and many of us feel that we are being forced to consider plans that could be improved for the benefit of engineers. I have written the Exploratory Group on this and suggested that each individual member of at least the 15 national societies that make up the Exploratory Group be polled to learn his wishes after he has had ample opportunity to study all plans, compromises, and worthy minority ideas. Among the latter there is an admirable plan (called Plan E) that has been submitted by the Florida Section of American Society of Civil Engineers. Unless engineers can be sure of what they want there will always be dissatisfaction and disunity.

At a very recent regional meeting of the American Society for Engineering Education (ASEE), at which I spoke on the unity situation, I was surprised to learn of the vital interest this large group of engineering educators had in the subject; of their almost unanimous dissatisfaction with the Plans A, B, C, and D; and their desire for more information and a better integrated plan to consider. A resolution was passed unanimously to that effect and forwarded to the national ASEE secretary. It turned out that only 5 out of the group had seen or heard much about the four plans before my talk. They were also keenly interested in having a plan that would be a real integration of technical and professional interests and one in which the individual could vote directly for its officers and director.

I am interested in real unity and not further disunity. I intend to support wholeheartedly any plan that the majority of engineers favor. Some of us want to be sure, however, that engineers have adequate opportunity to express their wishes on the plan they want. Such can hardly be done without a poll, or if they are told it must be one of the four plans or nothing.

T. H. EVANS

(Dean of Engineering, Colorado Agricultural and Mechanical College, Fort Collins, Colo.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AERODYNAMICS OF THE HELICOPTER. By Alfred Gessow and Garry C. Myers, Jr. The Macmillan Company, 60 Fifth Avenue, New York, N. Y., 1952. 243 pages, diagrams, charts, tables, illustrations, $8^1/_2$ by $5^3/_4$ inches, bound, \$6. A complete practical guide to the basic factors affecting the aerodynamic behavior of rotating-wing aircraft. The mechanisms and general flight and operating characteristics are first described. The aerodynamic theory of the rotor then is developed and applied to the prediction of helicopter behavior for all steady-flight conditions—power-on and autorotation. A bibliography of National Advisory Committee for Aeronautics papers on rotating-wing aircraft is included.

ALLGEMEINE WECHSELSTROMLEHRE. By H. F. Schwenkhagen. Volume I: Grundlagen. Springer-Verlag, Reichpietschufer 20, Berlin W 35, Germany, 1951. 544 pages, diagrams, tables, charts, 10 by 7 inches, bound, DM 39. This textbook in general a-c theory covers fundamentals applicable to power-supply systems, audio-frequency, and high frequency. Topics include circuits, alternating voltage, single-phase and multiphase current, transients in quasi-stationary circuits, and energy transmission in the rotating field.

D-C POWER SYSTEMS FOR AIRCRAFT. By R. H. Kaufmann and H. J. Finison. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 206 pages, charts, diagrams, illustrations, tables, $9^1/_2$ by 6 inches, bound, \$5. Aircraft power systems are studied from the viewpoint of how the individual electric devices work together to make up the complex system now necessary. Based both on theoretical analysis and on actual flight tests, the characteristics and performance of generators, storage batteries, control equipment, and circuits are analyzed and discussed.

DESIGN, CONSTRUCTION, AND OPERATING PRINCIPLES OF ELECTROMAGNETS FOR ATTRACTING COPPER, ALUMINUM, AND OTHER NONFERROUS METALS. By Leonard R. Crow. The Scientific Book Publishing Company, Vincennes, Ind., 1951. 38 pages, illustrations, diagrams, $8^1/_2$ by $5^1/_2$ inches, paper, \$1.25. Basic laws and technical details are given of electromagnets constructed by the author. Essential differences between these and the ordinary electromagnet are discussed.

ELEKTROSTATISCHE MESSGERATE. By A. Palm. Verlag und Druck G. Braun, Karl-Friedrich-Str. 14, Karlsruhe, Germany, 1951. 78 pages, illustrations, diagrams, $8^1/_2$ by 6, cloth, DM 12.50. Beginning with basic principles, this small book continues with concise, illustrated descriptions of present-day electrostatic instruments, both German and foreign, including uses, advantages, and limitations. It covers low-, medium-, and high-voltage meters of various design, and the use of electrostatic principles for other measurements such as resistance, phase displacement, and frequency.

FEHLER UND FEHLERSCHUTZ IN ELEKTRISCHEN DREHSTROMANLAGEN. By Hans Titze. Volume I: Die Fehler und ihre Berechnung. Springer-Verlag, Molkerbastei 5, Wein 1, Austria, 1951. 170 pages, charts, tables, diagrams, $9^3/_4$ by $6^3/_4$ inches, bound, \$5.70. In dealing with faults and fault protection in 3-phase systems this first volume discusses types of faults in power-supply systems (short circuits, grounds, oscillation, and so forth), the electrical phenomena associated therewith, and the mathematical methods for their calculation.

DIE FERNMESSUNG I. Allgemeines und Verfahren für kürzere Entfernungen. By S. John. Verlag und Druck G. Braun, Karl-Friedrich-Str. 14, Karlsruhe, Germany, 1951. 101 pages, diagrams, $8^1/_2$ by 6 inches, bound, DM 12.50. The 2-volume set, of which this is volume I, is intended to provide easily understood descriptions and explanations of the important up-to-date methods of remote metering for the use of engineers and operators of electric power systems, gas and water supply systems, mines, and so on. The present volume covers general principles and telemetering over limited distances where direct connection is possible.

AN INTRODUCTION TO THE ENGINEERING PROFESSION. By John G. McGuire and Howard W. Barlow. Addison-Wesley Press, Inc., Kendall Square Building, Cambridge 42, Mass., second edition, 1951. 260 pages, illustrations, tables, diagrams, $9^1/_4$ by $6^1/_4$ inches, bound, \$5. An occupational study of the principal fields of the engineering profession, discussing the nature of engineering aptitudes, requirements, preparatory courses, kinds of work involved, and prospects in the field. A section is devoted to illustrative problems in the various branches, primarily for use in a course on engineering problems, but also intended to show what the engineer must solve and how he goes about it.

THE MAGNETRON. By R. Latham, A. H. King, and L. Rushforth. Chapman and Hall Ltd., 37 Essex Street, London W. C. 2, England, 1952. 142 pages, illustrations, diagrams, charts, $8^3/_4$ by $5^1/_2$ inches, bound, 18s. The high-power, ultiresonator magnetron, with which this book is concerned, is the main radio-frequency generator used in a radar set. Three short chapters are devoted to relating the magnetron to other very-high-frequency transmitters and associated radar equipment. One chapter covers early developments, and the eight remaining chapters deal with the properties and theory of the anode block, electronic theory, cathodes, manufacture, and testing.

MICROPHONES. By the staff of the Engineering Training Department, British Broadcasting Corporation. Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S. E. 1, England, 1951. 114 pages, illustrations, diagrams, charts, $8^3/_4$ by $5^3/_4$ inches, bound, \$3.20. Originally written as a textbook for use in, training British Broadcasting Corporation engineers, this small volume covers the following topics: requirements for microphones in a broadcasting studio; sound waves and their behavior; operational forces acting in a microphone; electro-acoustics; diaphragm operation; detailed descriptions of the characteristics and performance of studio microphones.

MODERN MAGNETISM. By L. F. Bates. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., third edition, 1951. 506 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, \$5.50. As in earlier editions, the author avoids a strictly theoretical treatment by giving descriptions of fundamental experiments. Major contributions to the subject during the past ten years have been worked into the book at the appropriate places.

MUSICAL ENGINEERING. An Engineering Treatment of the Interrelated Subjects of Speech, Music, Musical Instruments, Acoustics, Sound Reproduction, and Hearing. By Harry F. Olson. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 369 pages, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, bound, \$6.50. A comprehensive elementary work on all aspects of the production and reproduction of sound, this book is for the use of any one interested in the study, measurement, and analysis of many types of audio problems. The fundamentals of musical production, including the construction and characteristics of instruments, are presented from an outline of musical notation through the physiological, mechanical, and acoustical aspects to sound-reproducing systems for radio, television.

NEON SIGNS AND COLD-CATHODE LIGHTING. By Samuel C. Miller. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., second edition, 1952. 395 pages, diagrams, tables, illustrations, $9^1/_2$ by 6 inches, bound, \$6. Primarily written for the manufacturer of luminous tube lighting equipment, this book discusses the design, manufacture, installation, and maintenance of neon signs. This second edition includes details of the operation and construction of fluorescent tubes, controlling devices, and radio and television interference from lighting systems.

POWER SYSTEM ANALYSIS. By J. R. Mortlock and M. W. Humphrey Davies. Chapman and Hall Ltd., 37 Essex Street, London, W. C. 2, England, 1952. 384 pages, diagrams, tables, charts, 9 by 6 inches, bound, 45s. This work is based on series of lectures concerning current difficulties and recent advances in the application of steady-state network theory to the problems encountered in power system engineering. The material goes from the solution of simple networks through the characteristics of underground cables, overhead lines, loads, stability, and so on, to a discussion of network analyzers and system design. The application of matrix algebra to network problems has been added to the material dealing with methods of computation and analysis.

"You mean a *loose slot stick* stopped that whole train?"

Certainly—but the report will say: "Motor failure was caused by a ground in the armature coil, 1 inch in from the end of the slot, pinion end." Overlooked in the report is the tiny slot stick, or wedge, which was made a couple of thousandths off size, or which was off a hair's breadth because of shrinkage. From it, coil vibration developed. Soon, a ground—motor failure—and *the train couldn't make the grade.* All over the world—in mines, in industry, in electric utilities—production trains can't make the grade because of "minor" failures deep in the bowels of motors and generators. National has demonstrated that the frequency of such "minor" failures can be drastically reduced. How? By insisting that every component which National supplies or installs must fit the particular job *that* motor or generator has to do—by refusing to be bound by standards set at some time in the obsolete past to fit general usage. We invite you to check the National record. We're proud of it.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

INDUSTRIAL NOTES ....

$500,000 Edison Laboratory. Charles Edison, Chairman of the Board and son of the founder of Thomas A. Edison, Inc., has broken ground for a new half-million-dollar Edison laboratory to be built in West Orange, N. J. The laboratory will be devoted to basic research and technical work directly supporting the operations of the company's seven manufacturing divisions.

Union Carbide Elections. The Union Carbide and Carbon Corporation has elected Morse G. Dial as President (succeeding Fred H. Haggerson, who continues as Chairman of the Board); Walter E. Remmers as Vice-President—Alloys Division; and Kenneth H. Hannan as Treasurer.

Youmans Elected Okonite Director. E. D. Youmans, Vice-President in charge of manufacturing and research, has been elected to The Okonite Company's Board of Directors.

Kollsman Appointment. Rear Admiral Clyde W. Smith, United States Navy, retired, has been made assistant to the president of the Kollsman Instrument Corporation, a wholly-owned subsidiary of Standard Coil Products Company, Inc.

Marx Made Director of Du Mont International Division. Ernest A. Marx has been appointed Director of the International Division of the Allen B. Du Mont Laboratories, Inc. Also, Lewis E. Pett has been named western district manager for the company's television transmitter division.

General Electric News. The General Electric Company's Tube Department has announced plans for operation in Chicago, Ill., of a new $875,000 electronic tube warehouse, which will serve as sales headquarters, warehouse center, and commercial service headquarters for the Tube Department's central region operations. The new facilities will be so extensive that five freight cars and five giant trailer trucks can be loaded simultaneously. Another announcement from the company concerns three new buildings which have been added to their transformer and allied products division facilities at Pittsfield, Mass. The buildings, which cost more than six million dollars, will provide facilities for the manufacture of laminated cylinders for insulating transformer coils, production of copper conductors for transformers, and testing of high-voltage bushings. In addition, the company's lamp division has moved into new headquarters at 6500 Cedar Springs Avenue, Dallas, Tex.

Recent appointments at the company include the election of James J. Slattery as Vice-President and general sales manager of General Electric Appliances, Inc., and the election of Harry P. Gough as a Vice-President of the General Electric Credit Corporation in charge of business development.

Lenkurt Elects Two Vice-Presidents. Philips B. Patton and George F. Koth have been elected Vice-Presidents of the Lenkurt Electric Company, Inc.

Strock Joins Sylvania. Dr. Lester W. Strock has joined the staff of the physics laboratory of Sylvania Electric Products, Inc., as an engineering specialist. Dr. Strock will work in the fields of spectroscopy, X-ray diffraction, and crystallography. Sylvania has also announced the appointment of A. W. Keen as manager of application co-ordination.

Parker Named President of Daystrom Instrument. George J. Parker, formerly Vice-President of Daystrom, Inc., has been made President of the Daystrom Instrument Division of that company.

Julius B. Wantz Dies. Julius B. Wantz, holder of more than 50 patents in the field of X-ray and electromedical apparatus, and a pioneer in adapting electricity to medicine, died recently. Mr. Wantz was a cofounder of the General Electric Company's X-ray department, which began in 1893 in a basement workshop in Chicago, Ill.

National Electric Products Establishes New Division. The National Electric Products Corporation has established a new electronics division consisting of two departments—Television and Radio, and Radar. The Television and Radio Department will be located at the Ambridge, Pa., plant, and the Radar Department will be located at the corporation's new million-dollar Elizabeth, N. J., plant.

Ultrasonic Acquires Monitor Controller Company. The Ultrasonic Corporation, Cambridge, Mass., has acquired The Monitor Controller Company of Braintree, Mass. Ultrasonic will use Monitor's production facilities for the manufacture of certain of its sonic and electronic computer equipment in addition to the continued manufacture of Monitor's products.

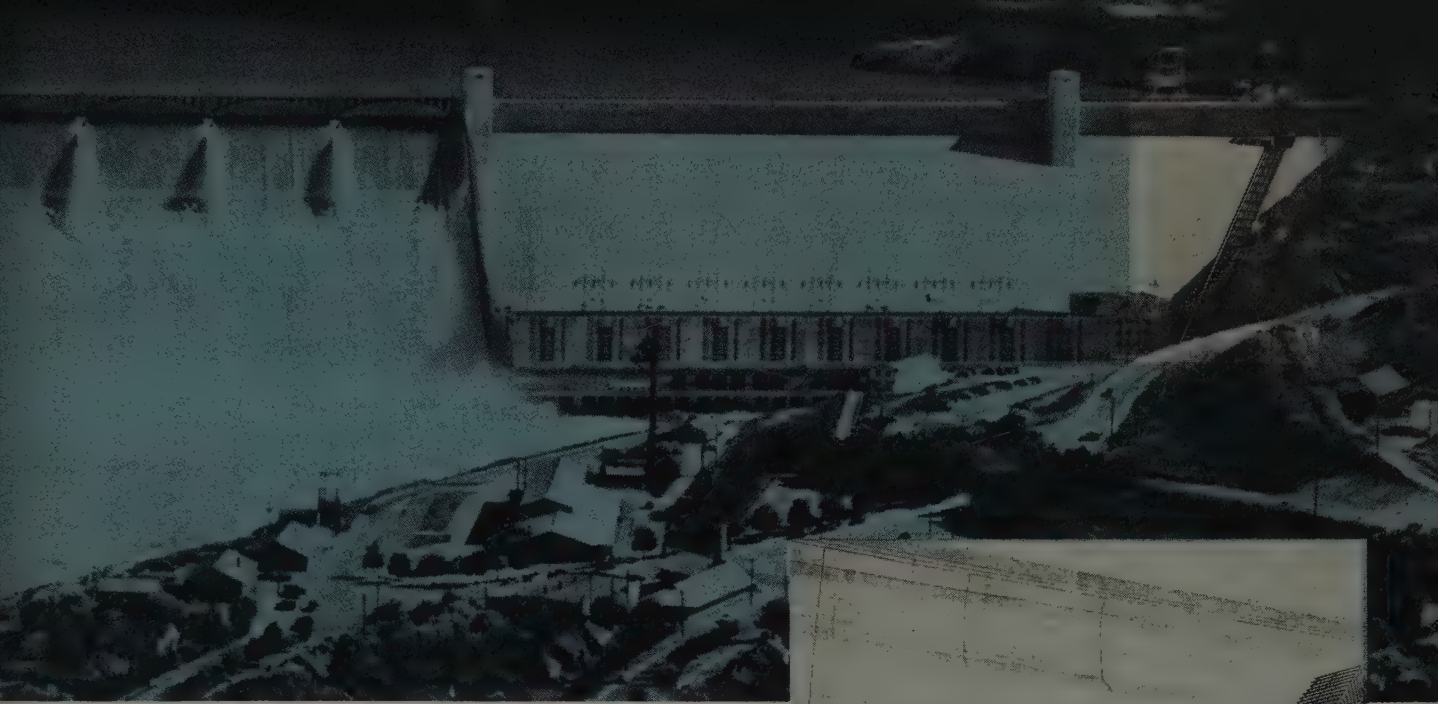
Westinghouse Appointment. H. R. Arnold has been made assistant to the manager of the aviation gas turbine division of the Westinghouse Electric Corporation.

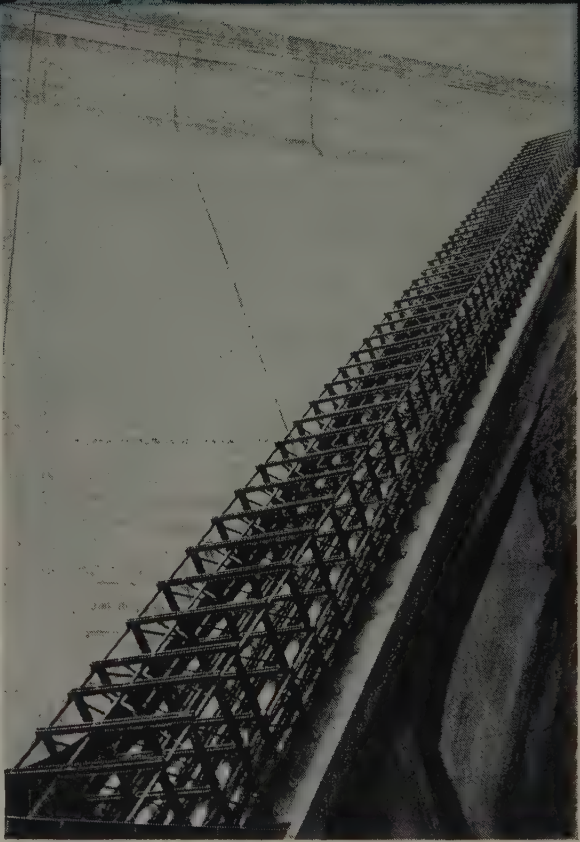
Larkin Lectro Changes Name. The Larkin Lectro Products Corporation has changed its name to that of the Central Transformer Corporation.

NEW PRODUCTS • •

Automatic Voltage Booster. The Sola Electric Company has developed a new automatic single-step voltage booster de-

(*Continued on page 20A*)





SIX PUMP BUS RUNS

The Grand Coulee pumping station will ultimately house 12 giant pumping units, each powered by a 65,000-hp, 200-rpm, 13.6-kv, 3-phase, 60-cycle synchronous motor. *Six pumps are now in service. Six others are planned for future installation.*

Power for this pumping service is supplied by three of the main generators, each generator feeding *two* pump motors. The three I-T-E Isolated Phase Bus runs now installed carry power—4300 amperes in each circuit—260 feet up the face of the dam. Six branch buses, rated at 2150 amperes each, connect the pump motors.

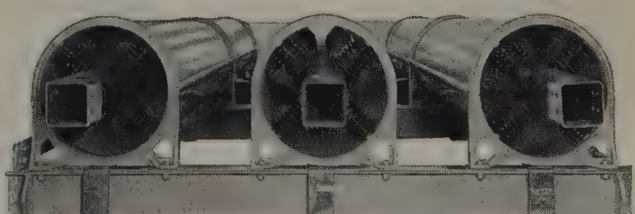
This I-T-E bus connection—comprising *9000* single-phase feet—is the longest structure of its kind in the world.

DESIGNED FOR MAXIMUM SERVICE CONTINUITY

Principal feature of these I-T-E bus runs is unique *isolated phase* construction. Each conductor is encased in an *individual* non-magnetic housing. Each housing is separated from adjacent housings by an insulating air space. *Phase-to-phase short circuits are virtually eliminated!*

MORE THAN 30 CONDUCTOR-MILES IN 277 INSTALLATIONS

I-T-E Isolated Phase Bus has been transmitting power from the world's largest generators since 1936—providing power plants with safe, dependable service.



I-T-E ISOLATED PHASE BUS

I-T-E CIRCUIT BREAKER CO. • 19th AND HAMILTON STS., PHILA. 30, PA.

CANADIAN MFG. AND SALES: EASTERN POWER DEVICES, LTD., TORONTO • EXPORT SALES: PHILIPS EXPORT CORP., N.Y., N.Y.

(*Continued from page 16A*)

signed to handle motor starting loads in areas where fluctuating low voltages are prevalent. Its completely automatic operation is based on use of a voltage-sensitive a-c control. If the line voltage drops to about 105 volts or below, the booster is automatically connected into the circuit. When the line voltage rises to about 110 volts or more, the booster is automatically disconnected. The booster plugs into the regular line outlet and the motor power cord into the booster socket. No wiring or installation is required. Load capacity is 2,000 volt-amperes for model *92004;* 5,000 volt-amperes for model *92005.* Approximate voltage boost is 12 per cent. Bulletin *39J SCA-37*, which describes the booster more thoroughly, is available from the Sola Electric Company, 4633 West 16th Street, Chicago 50, Ill.

Antistatic Agent. Anstac M is a new liquid antistatic agent introduced by the Chemical Development Corporation, Danvers, Mass. It may be applied by spraying, brushing, dipping on plastic, glass, or painted surfaces. The treated product is static-free. Further information may be obtained from the company.

Load Pickup Sectionalizer. A load pickup sectionalizer, type *LPS*, has been developed by the Westinghouse Electric Corporation. Used in connection with reclosing circuit breakers or reclosers, the sectionalizer enables distribution circuits to be picked up after long power outages without manual operations normally required. It automatically compensates for the power demand that accumulates during an outage. If the accumulation is enough to cause reclosing circuit breakers to operate, the *LPS* will temporarily disconnect part of the load. The load is reconnected after a predetermined time delay by a self-contained timing relay. Under fault conditions, the sectionalizer operates a conventional automatic line sectionalizer. It can also serve as a manual loadbreak switch. The unit supports 15-kv line bushings. The series coils can be had in ratings from 5 to 100 amperes; control relay voltage can be either 110 or 220 volts alternating current. The Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa., will supply any further details.

Electronic Voltmeter. The Ballantine Laboratories, Inc., Boonton, N. J., has introduced a wide-band electronic voltmeter. When used normally with its probe it will measure (by means of a 6-decade range switch) from 1 millivolt to 1,000 volts alternating current in the range 15 cycles to 6 megacycles with an input impedance corresponding to 11 megohms shunted by 6 micromicrofarads. Omitting the probe permits measurements to be made in the range 100 microvolts to 1 millivolt, but the input impedance is reduced to 1.11 megohms shunted by 25 micromicrofarads. A coaxial output connector permits the amplifier section to

(*Continued on page 38A*)

Oil Immersed

Rowan engineers designed and developed the original 2300-V self-supporting and self-contained motor control of the cubicle construction for indoor and outdoor service.

Standard units consist of: a self-contained, insulated bus; a self-contained control potential transformer; current-limiting or high-interrupting capacity fuses; a specially designed, quick-acting, heavy-duty contactor with non-freezing contacts; sealed-off motor lead compartment; separate low-voltage control compartment; magnetic overload relays with electric reset, instantaneous and inverse time element—and a self-contained, tank lowering device.

Additional features such as watt-hour meter, voltmeter, ammeter, potential switch, etc., can be had to meet the requirements for specific applications.

Rowan sales offices are conveniently located throughout the country. A representative is quickly available to give you complete information.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

(Continued from page 20A)

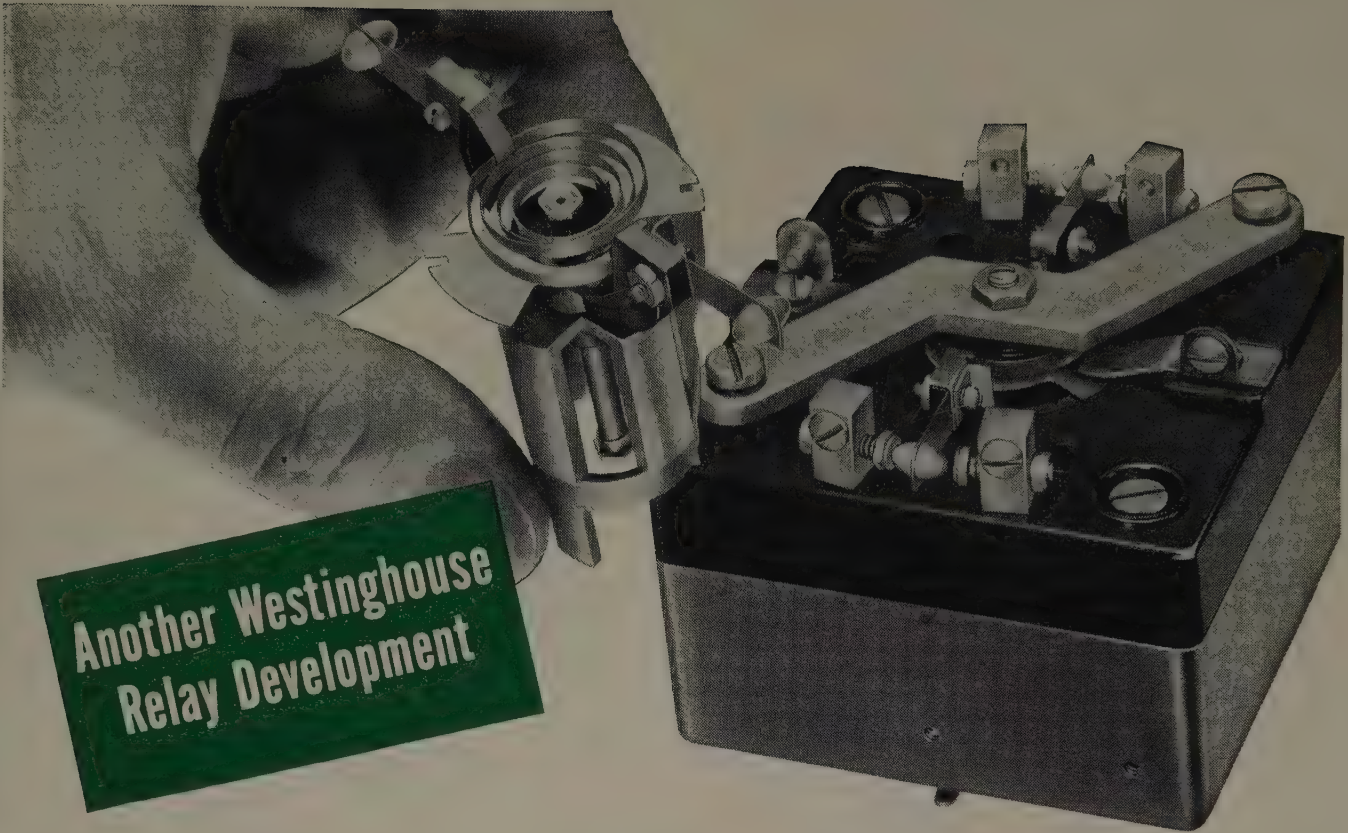
be used as a wide-band amplifier having a maximum gain of 60 decibels variable in 20-decible steps. The amplifier has an output impedance of 600 ohms and when connected to a load of not more than 25 micromicrofarads, the frequency response is flat within 1/2 decibel from 100 cycles to 3 megacycles and within 1 decibel from 50 cycles to 6 megacycles. Power supply is 110–120 volts, 50 to 60 cycles, 40 watts. Instruments for 220–240 volts are also available. The Ballantine Laboratories will furnish any additional information.

Ultrasonic Viscosimeter. The Rich-Roth Laboratories have developed the "Ultra-Viscoson" for continuous, automatic viscosity measurement of liquids using ultrasonics. The hermetically sealed probe, the size of a fountain pen, has no moving parts, operates to 650 degrees Fahrenheit, 10,000 atmospheres pressure, and can be installed permanently in pipe lines, production kettles, or used in test tubes and beakers. The electronic computer, located up to 1 mile from the probe, indicates the viscosity of Newtonian materials from zero to 50,000 centipoises × grams/cubic centimeters in 4 decades—0/50/500/5000/50000. The viscosity of non-Newtonian materials can be measured over a much greater range. This Ultra-Viscoson can be connected to a recorder or a controller, providing continuous charts or automatic control. Power requirement is 100 to 130 volts alternating current, 60 cycles, 100 watts. Rich-Roth Laboratories, 673 Connecticut Boulevard, East Hartford 8, Conn., will supply any further details.

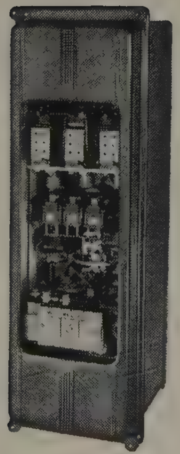
Power Tetrode Transmitting Tube. The RCA Victor Division of the Radio Corporation of America, Camden, N. J., has announced its most powerful very-high-frequency power tetrode transmitting tube, a forced-air-cooled 10-kw type featuring a thoriated-tungsten filament. The tube, *RCA-6166*, is rated for operation up to 220 megacycles, and can deliver a synchronizing-level power output of 12,000 watts in broad-band television service at 216 megacycles. Forced-air cooling, effected by an external radiator, makes possible substantial operating economies, as well as simplification of transmitter design and conventional heat-dissipation equipment. The thoriated-tungsten filament requires 60 to 70 per cent less filament power than pure-tungsten types, operates at a temperature of 500 to 600 degrees lower, and has 10 to 15 times greater electron-emission efficiency. Mr. Harold Desfor, Press Director of the company, will furnish additional information desired.

Fusistor. The "Fusistor" is a resistance unit that under normal electric load will operate as a resistor only, but when it is subjected to an overload of current, will sustain the overload for a predetermined time, then melt or burn out before expira-

(Continued on page 50A)



New double-loop directional element ELIMINATES VIBRATION...



The Type HZM, and Type HZ, high-speed impedance relays are now available with the new double-loop directional element.

Westinghouse High-Speed Impedance Relays now offer you extra operating benefits. A new directional element, featuring double-loop design, eliminates troublesome 120-cycle vibration.

The torque produced in each loop is a double frequency sine wave. However, as these waves are 180 degrees out of phase and offset in the same direction, the net torque in both loops is a constant value—eliminating vibration. The result is an efficient, high-speed directional element, providing low burden, good sensitivity in a sturdy rugged enclosure . . . a sharper intelligence for vital relaying applications.

For complete information write for Silent Sentinel Bulletin No. B-5297. Address: Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40402

YOU CAN BE SURE.. IF IT'S

Westinghouse

RELAYS

(Continued from page 38A)

tion of another given predetermined time, thus functioning as a fuse. The overload time-lag can be established within closely controlled minimum and maximum time limits. There is no flame, or spark emission, at the moment of fusion. The Milwaukee Resistor Company, manufacturers of the Fusistor, at 700 West Virginia Street, Milwaukee 4, Wis., will supply further information.

Super-High-Frequency Test Sets. Two new test sets for super-high-frequency work have been announced by the Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, Calif. Model *624A SHF* offers continuous frequency coverage over the 8,500- to 10,000-megacycle range. The equipment is essentially a signal generator providing a maximum radio-frequency output of 0.223 volt. It may be modulated with high quality pulses of 0.05 microsecond rise time; or may be frequency modulated. A separate receiver section measures external radio-frequency power or external frequency, and special circuits assure that pulse power level is equal to the continuous wave level. Model *623 SHF* has an over-all frequency range of 5,925 to 7,725 megacycles, with operating frequency ranges determined by the klystron tube that is installed. Six separate klystrons, with ranges of 300 megacycles each, are available. The Hewlett-Packard Company will supply any additional information desired.

Controlens. The Holophane Company's latest luminaire development is the *F-1570*, which features a larger lens and a narrower trim with a square prismatic reflector and a concave Controlens. By using this Controlens, high brightness, necessary for efficiency, is always on the near side of the lens and thereby shielded from the observer at any normal viewing angle. Lamp wattage is 300. More complete information is available from the Holophane Company, Inc., 342 Madison Avenue, New York 17, N. Y.

Oscilloscope. The new model *401* oscilloscope developed by the Laboratory for Electronics, Inc., 75 Pitts Street, Boston 14, Mass., is a high-gain wide-band general-purpose instrument capable of quantitative measurements of high and low speed electrical phenomena. It is suited for precise examination of pulse waveforms and transient phenomena, in addition to customary oscilloscope applications. Features are: (Y-axis) deflection sensitivity—15 millivolts peak-to-peak per centimeter; frequency response—direct current to 10 megacycles; transient response—rise time—0.035 microsecond; signal delay—0.25 microsecond; input line terminations. (X-axis): Sweep range—0.01 second per centimeter to 0.1 microsecond per centimeter; delayed sweep range—0 to 5,000 microseconds in three ranges, continuously adjustable; triggers—internal or external, plus and minus, 60 cycles, or delayed trigger outputs are available A booklet supplying further details on this

(Continued on page 62A)

important

NEW WINDING FORMS AND TECHNIQUES— NEW TYPE INSULATION — NEW TERMINATIONS — GIVE NEW CLOSE TOLERANCE EFFICIENCY

New Winding Forms hold more wire—provide higher resistance values. Non-hygroscopic ceramic forms assure high insulation qualities, high mechanical strength, and low coefficient of thermal expansion.

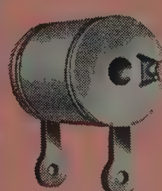
New Winding Technique, developed by IRC engineers, eliminates possibility of shorted turns or winding strains. All wire used receives rigid insulation tests of special enamel coating. Additional production tests assure high quality in the finished resistor.

New Type Insulation insures long life under *all* environmental conditions. Winding is multiple vacuum impregnated with a new compound developed by IRC chemists. This has the unique characteristic of retaining the same consistency throughout the entire range of temperatures to which the resistors may be subjected. It is neither glassy hard nor tacky soft under any conditions. Result:—A higher degree of stability and freedom from noise, and much greater resistance to humidity.

Typical Cycling and Load Tests Show Minimum Change in Resistance of New IRC Precision Wire Wounds

A glance at the adjacent chart will show the negligible resistance change undergone by IRC Precision Wire Wounds subjected to the most stringent and protracted cycling and load tests. Here is your assurance that new IRC Precision Wire Wounds withstand the toughest kind of service without loss of efficiency. This is only one of the many rigid tests applied to IRC Precision Wire Wounds.

	Original Resist.	1st Cycle % Chge	2nd Cycle % Chge	3rd Cycle % Chge	4th Cycle % Chge	Resist. at End of 100 hrs. load	Total % Chge	% Chge from Last Temp. Cycle to End of 100 hrs. load %	Resistance Chge at End of 100 Hrs. Load only % (no cycling)	
1	100,010	+.04	+.04	+.05	+.05	100,050	+.04	—.01	100,040	—.02
2	100,000	+.03	+.04	+.03	+.05	100,060	+.06	+.01	100,000	0
3	100,000	+.01	+.02	+.02	+.05	100,000	0	+.05	100,050	—.02
4	100,000	+.02	0	+.02	+.02	100,000	0	—.02	100,040	—.01
5	100,010	+.03	+.04	+.04	+.05	100,000	0	—.05	100,030	—.03
6	100,000	0	+.03	+.04	+.04	100,100	+.1	+.06	99,980	0
7	100,000	+.04	+.05	+.04	+.04	100,070	+.07	+.03	100,000	0
8	100,000	+.03	+.05	+.05	+.05	100,050	+.05	0	100,000	0
9	100,000	+.04	+.03	+.05	+.04	100,010	+.01	—.03	100,050	0
10	100,000	+.02	+.02	+.02	+.04	100,010	+.01	—.03	100,000	0
11	100,000	0	+.01	+.01	+.03	100,000	0	—.03		

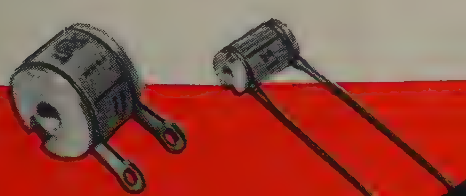


New Terminations. All precision resistors, with the exception of WW-10, are provided with rugged lug terminals for solder connections. These provide dependable and strain-free winding terminations. WW-10, because of its small size, has wire lead termination 2'' long.

SIZES AND RANGES

JAN-R-93.	1 5/32" Max.	29/32" Max.	27/32" Max.	13/16" Max.		3/4" Max.	Dia.
	2 1/8" ± 1/16"	1 1/8" ± 3/16"	1" Max. 7/8" Min.	5/8" ± 1/16"		15/32" Max.	Length
	4.00 Meg.	750,000	300,000	300,000		185,000	Max. Range
Style	RB14	RB13	RB12	RB11	RB11	RB10	None
New IRC Style #	WW2J	WW5J	WW4J	WW11J	WW3J	WW8J	WW10J
Dia.	7/8" D	3/4" D	9/16" D	9/16" D	9/16" D	9/16" D	9/32" D
Length	2 1/8" L	1 1/4" L	1" L	21/32" L	9/16" L	29/64" L	13/32" L
No. of Pies	8	4	4	2	2	1	1
J. A. N. .0015" Dia.	4.250 Meg.	1.5 Meg.	0.5 Meg.	0.300 Meg.	0.185 Meg.	0.185 Meg.	40,000 Ohms.
Commercial .0013" Dia.	6.00 Meg.	2.7 Meg.	0.9 Meg.	0.450 Meg.	0.225 Meg.	0.225 Meg.	80,000 Ohms.
.0013" Dia. 1000 Alloy							100,000 Ohms.

Test the IRC Industrial Service Plan and you'll always use it to get maintenance, pilot-run or experimental quantities of standard resistors in a hurry. Your nearby IRC Distributor has these units on his shelf, can make 'round-the-corner delivery without delay. He's a good man to talk with about JAN Specifications, too. Ask for his name and address.



Power Resistors • Voltmeter Multipliers • Insulated Composition Resistors • Low Wattage Wire Wounds • Volume Controls • Voltage Dividers • Precision Wire Wounds • Deposited Carbon Precistors • Ultra-HF and High Voltage Resistors • Insulated Chokes.

IRC

Wherever the Circuit Says —^^^—

INTERNATIONAL RESISTANCE COMPANY

401 N. Broad Street, Philadelphia 8, Pa.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

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Mail Coupon today for Full Details of New IRC Precision Wire Wounds in Technical Data Bulletin D-3

INTERNATIONAL RESISTANCE CO.
411 N. Broad St., Philadelphia 8, Pa.

Please send me Technical Data Bulletin D-3 ☐, and/or name and address of nearest IRC Distributor ☐

NAME________________________

TITLE________________________

COMPANY________________________

ADDRESS________________________

CITY____________ZONE______STATE______

(Continued from page 50A)

oscilloscope is available from the Laboratory for Electronics.

Cast-Permafil Transformer. A new hermetically-sealed transformer with cast-permafil construction for use in radar and other military electronic equipment has been introduced by the Specialty Transformer and Ballast Department of the General Electric Company. This solventless-resin-type transformer has sufficient moisture protection to meet a specification written for metal-enclosed hermetic units, and averages about 20 per cent smaller than previous models. This is largely the result of anchoring the terminals directly in the permafil mixture rather than through a steel cover. The casting materials are fungusproof. The transformers have been subjected to arduous accelerated life tests which indicate that at 105 degrees centigrade ultimate temperature, they will last as long as standard class *A* hermetics, and at 130 degrees centigrade ultimate temperature, a life of 1,000 hours or more can be expected. The transformer is available at present only in limited quantities for developmental programs, but the General Electric Company, Schenectady 5, N. Y., will furnish additional information upon request.

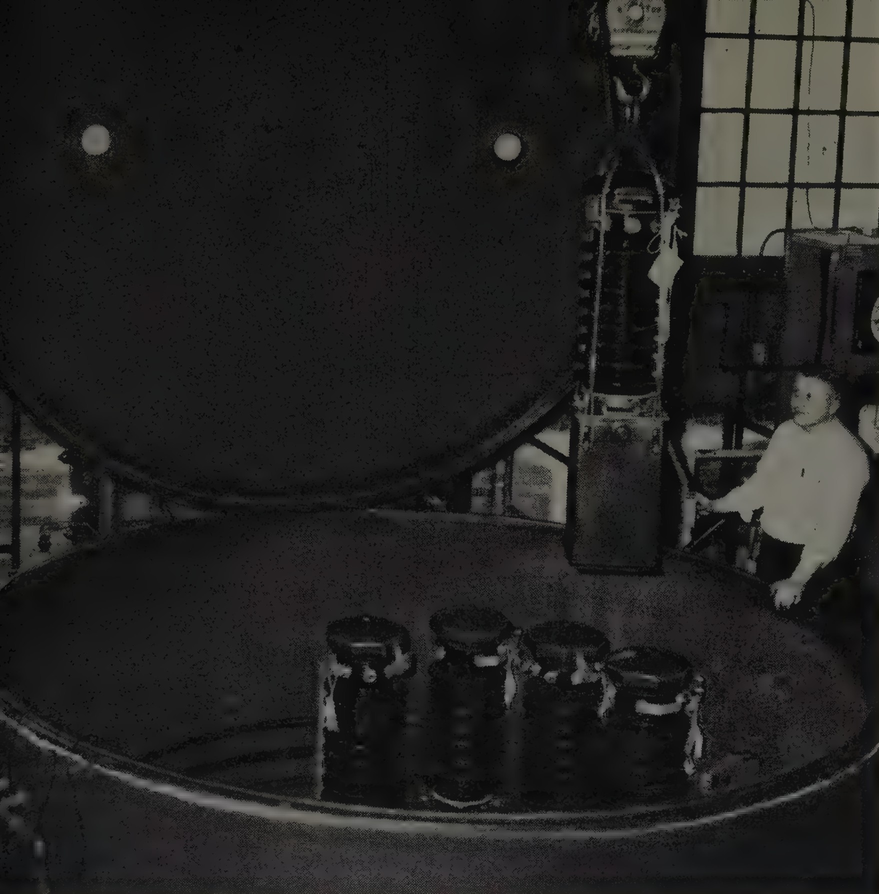
Low-Voltage Capacitors. A new line of hermetically sealed corrosion-resistant capacitors for radio interference suppression on the low-voltage electric systems of military vehicles and portable gasoline-driven power plants has been developed by the Sprague Electric Company, 15 Marshall Street, North Adams, Mass. These metal-encased capacitors withstand severe shock and vibration as well as atmospheric moisture and salt spray. Capacitance values of 0.01, 0.1, 1.25, and 0.5 microfarad are available. Extended coil (noninductive) capacitor sections and a short, direct lead between the ungrounded coil and its heavy terminal assure minimum radio-frequency impedance and maximum by-passing efficiency. Bulletin *217* giving further details is available on letterhead request to the Sprague Electric Company.

TRADE LITERATURE

Fundamentals of Instrumentation. "Fundamentals of Instrumentation for the Industries" is the title of a new 126-page booklet, number *80-2*, available upon request from the Minneapolis-Honeywell Regulator Company, Brown Instruments Division, Station 40, Wayne and Windrim Avenues, Philadelphia 44, Pa. The booklet covers the fundamentals of measurement, control, and transmission of variables encountered in industry.

The company has also published bulletin *85-20*, "Centralized Instrumentation Unlimited," which describes in 32 pages the conventional and graphic-type panelboards, as well as the measuring and con-

(Continued on page 72A)



ANSFORMERS ARE PLACED IN VACUUM TANK TO REMOVE MOISTURE FROM WINDINGS

FLEXIBLE LINE TERMINALS are welded to studs. Copper straps connected to studs provide for making series and multiple connections on primary coils without opening transformer.

PORCELAIN BUSHING CEMENTED to top and bottom rings. For greatest strength, cement is steam-oven-cured and wet-process porcelain is straight in design rather than tapered.

ow G.E. Builds High-voltage Instrument ransformers for Dependable Operation

URING FINAL ASSEMBLY, bushings are ted on base tanks, maintaining uniform essure. Long-life nitrile rubber gaskets e the result of years of G-E research.

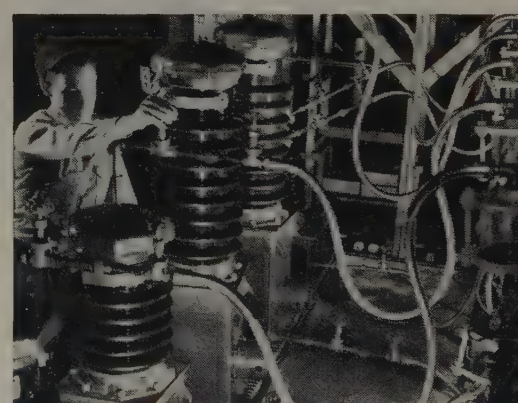
Built for heavy-duty service, General Electric's Type KG current transformers offer both dependable operation and high, sustained accuracy. Each manufacturing operation, each design detail contributes to sturdy construction and long life.

Core and coils are mounted in a shallow tank and coil leads extend up through a heavy insulating barrier into a porcelain housing which acts as a primary bushing.

HIGH SUSTAINED ACCURACY

Exclusive features of G-E Spirakore core, for example, assure higher degree of accuracy. Another help: secondary winding is uniformly distributed around core. Transformers are suitable for accurate metering service down to five per cent of the primary current rating and for relay operation up to twenty times full-rated current.

They're available in 25,000- to 69,000-volt ratings. For complete details, see your G-E representative. General Electric, Schenectady 5, New York.



FILLING STATION slowly injects de-aerated oil while a vacuum is held, impregnating the insulation. Previously, tank was partly filled with sand to keep oil expansion to a minimum.

TO ASSURE HIGH ACCURACY, each completed transformer receives rigid ratio and phase-angle tests which prove that it is well within ASA accuracy-standard classification.

GENERAL ELECTRIC

604-32

(*Continued from page 62A*)

trol instruments utilized. This booklet also may be obtained upon request.

Television Receiver Service Guide. The second edition of the General Electric Company's television receiver service guide which contains information on 102 General Electric chassis, schematic diagrams with circuit symbol numbers, tube locations, and cabling diagrams, has been issued. It is priced at $1.00 and may be obtained from the General Electric Company at Electronics Park, Syracuse, N.Y.

Preventive and Electrical Maintenance. Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa., has published two new booklets: number *B-5477*, which gives a complete outline of a successful preventive maintenance program for any industry; and booklet *B-4766*, which describes a complete maintenance service for electric apparatus. Copies are available upon request.

Automatic Circuit Reclosers. The R & IE Equipment Division of the I-T-E Circuit Breaker Company, Greensburg, Pa., has made available a bulletin, *1550A*, which describes their automatic circuit reclosers.

Floatless Liquid Level Controls. The B/W Controller Corporation has published a 36-page booklet on floatless liquid level and industrial controls. The booklet may be obtained by writing to the company at 2200 East Maple Road, Birmingham, Mich.

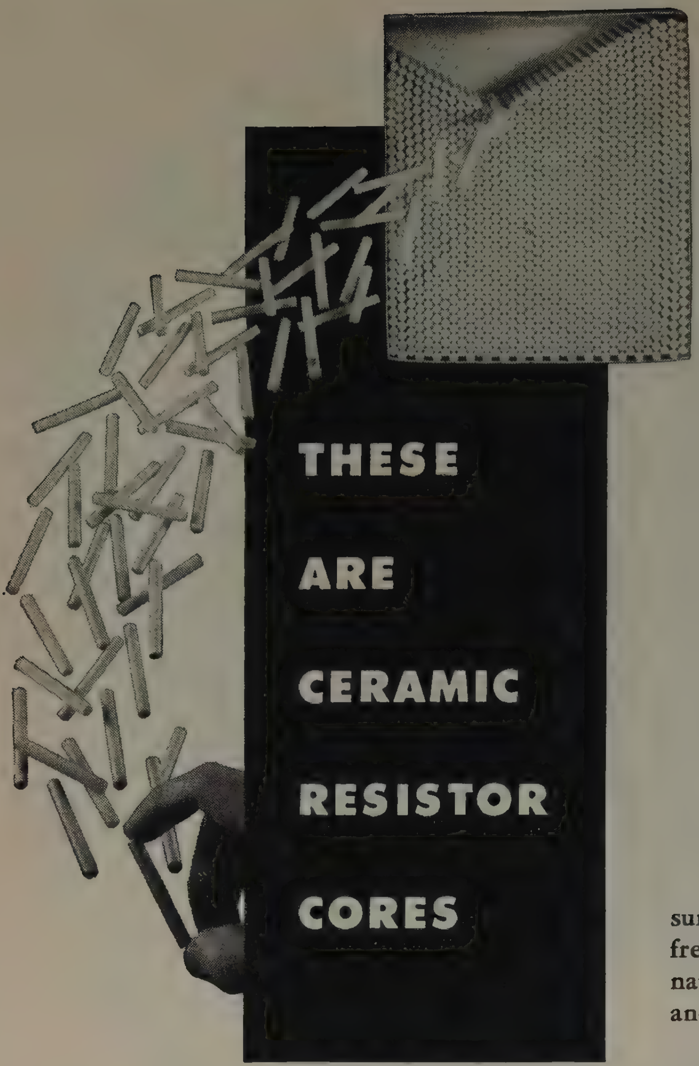
Polyform. A new group of room-temperature cure plastic casting materials developed by the B. G. Forman Company, Inc., 181 Throop Avenue, Brooklyn, N.Y., for potting and encapsulating transformers and electronic assemblies are described in a bulletin, "Polyform," which may be obtained upon request.

Textile Motor and Control. The application of both motors and their controls to the textile industry is the theme of a new 32-page booklet available from Westinghouse. In addition, reply cards are provided to speed handling of requests for any of 35 special applicable publications listed in this booklet, number *B-5422*. Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa., will supply copies.

Building Materials Reference Manual. A new Reference Manual produced by The Philip Carey Manufacturing Company contains a complete listing of 800 building materials and industrial products obtained from asbestos, asphalt, or magnesia, along with their specifications. Requests for copies should be sent to The Philip Carey Manufacturing Company, Department *FRM*, Cincinnati 15, Ohio.

Demodulator. The Lenkurt Demodulator is a new house organ for those interested in the field of telephone and telegraph carrier equipment. Requests for this copy and future ones, should be sent to the Publications Department, Lenkurt Electric Company, San Carlos, Calif.


This sectionalizing switch in an "express" feeder uses a simple method of by-passing for routine maintenance. The hot line tap of the by-pass jumper is moved to the opposite side of insulating member; then the switch leads are removed, without requiring the lineman to climb through primary lines or interrupt service.
4427 Ravenswood Avenue
Chicago 40, Illinois, U. S. A.
Formerly
SCHWEITZER & CONRAD, INC.



They are coated by the deposition of gaseous carbon; after coating, a spiral groove cut through the surface of the "rod" lengthens the current path to provide required value of resistance.

They appear to be simple pieces, and they are produced by Lapp in the millions, at a very few cents each. Yet as a development and production accomplishment, their simpleness is a deception indeed. Physically and electrically they are something quite "special" as a ceramic achievement.

Dimensionally, they admit a tolerance of only ±.005″ in diameter, ±.010″ in length. Ends are square, accurately beveled. Rods are ruler-straight, and roundness is maintained within .001″. The nature of the surface is critically important, too. It must be wholly free of pits, striae, ridges or other blemishes, and of a nature that will "take" the carbon coating smoothly and in uniform thickness.

In addition, a paramount consideration in this extremely fine type of resistor is *constant resistance* against temperature change and time—within a far narrower range than is possible with regular electrical porcelain or steatite. This requirement has been met by development of a special alkaline earth fluxed porcelain body. Production of this body is a delicate matter; the critical firing range, for example, is only one-fifth that of porcelain insulators.

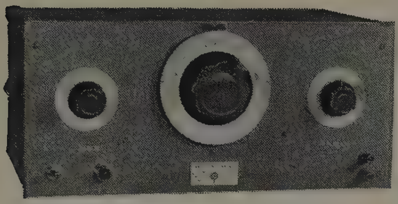
Lapp is proud of its ability to develop and produce a special component to such demanding specifications. But our real pride is in the ceramic ingenuity, and in the ceramic control techniques that make such accomplishments possible. These are the factors, we are sure you will agree, that add permanent value and quality, to the end of superior performance, to every Lapp insulator and to every piece of Lapp porcelain for any electrical duty.

Lapp Insulator Co., Le Roy, N. Y.

Lapp

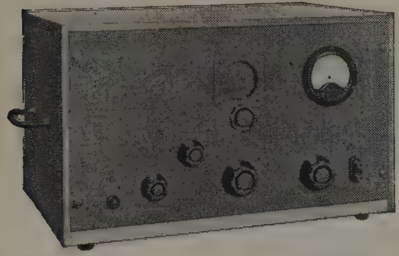
Accurate ac test voltages ½ to 10,000,000 cps

Complete Coverage



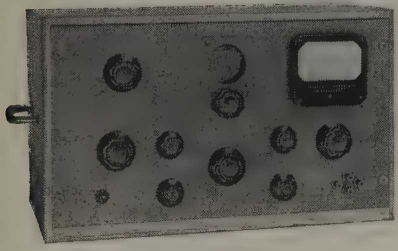
-hp- 200 Series Audio Oscillators

Six standard models, -hp- 200A and 200B have transformer-coupled output delivering 1 watt into matched load. -hp- 200C and 200D have resistance-coupled output and supply constant voltage over wide frequency range. -hp- 202D is similar to 200D, with lower frequency range. -hp- 200I is a spread-scale oscillator for interpolation or where frequency must be known accurately.



-hp- 650A Resistance-Tuned Oscillator

Highly stable, wide band (10 cps to 10 mc), operates independently of line or tube changes, requires no zero setting. Output flat within 1 db. Voltage range 0.00003 to 3 volts. Output impedance 600 ohms or 6 ohms with voltage divider.



-hp- 206A Audio Signal Generator

Provides a source of continuously variable audio frequency voltage with less than 0.1% distortion. Very high stability, accuracy 0.2 db at any level. Specially designed for testing high quality audio circuits, checking FM transmitter response and distortion, broadcast studio performance or as a low distortion source for bridge measurements, etc.

INSTRUMENT	PRIMARY USES	FREQUENCY RANGE	OUTPUT	PRICE
-hp- 200A	Audio tests	35 cps to 35 kc	1 watt 22.5v	$120.00
-hp- 200B	Audio tests	20 cps to 20 kc	1 watt 22.5v	$120.00
-hp- 200C	Audio and supersonic tests	20 cps to 200 kc	100 mw 10v	$150.00
-hp- 200D	Audio and supersonic tests	7 cps to 70 kc	100 mw 10v	$175.00
-hp- 200H	Carrier current, telephone tests	60 cps to 600 kc	10 mw 1v	$350.00
-hp- 200I	Interpolation and frequency measurement	6 cps to 6 kc	100 mw 10v	$225.00
-hp- 201B	High quality audio tests	20 cps to 20 kc	3 w/42.5v	$250.00
-hp- 202B	Low frequency measurements	½ cps to 50 kc	100 mw 10v	$350.00
-hp- 202D	Low frequency measurements	2 cps to 70 kc	100 mw 10v	$275.00
-hp- 204A	Portable, battery operated	2 cps to 20 kc	2.5 mw/5v	$175.00
-hp- 205A	High power audio tests	20 cps to 20 kc	5 watts	$390.00
-hp- 205AG	High power tests, gain measurements	20 cps to 20 kc	5 watts	$425.00
-hp- 205AH	High power supersonic tests	1 kc to 100 kc	5 watts	$550.00
-hp- 206A	High quality high accuracy audio tests	20 cps to 20 kc	+ 15 dbm	$550.00
-hp- 650A	Wide range video tests	10 cps to 10 mc	15 mw 3v	$475.00

Data subject to change without notice. Prices f. o. b. factory.

Whatever ac test voltage you need—whatever frequency or magnitude you require—there is an *-hp-* oscillator or generator to provide the exact signal desired.

-hp- oscillators offer complete coverage, ½ cps to 10,000,000 cps. They are dependable, fast in operation, easy to use. They bring you the traditional *-hp-* characteristics of high stability, constant output, wide frequency range, low distortion, no zero set during operation.

-hp- oscillators and audio signal generators are used by manufacturers, broadcasters, sound recorders, research laboratories and scientific facilities throughout the world. For complete details on any *-hp-* instrument, see your *-hp-* sales representative or write direct.

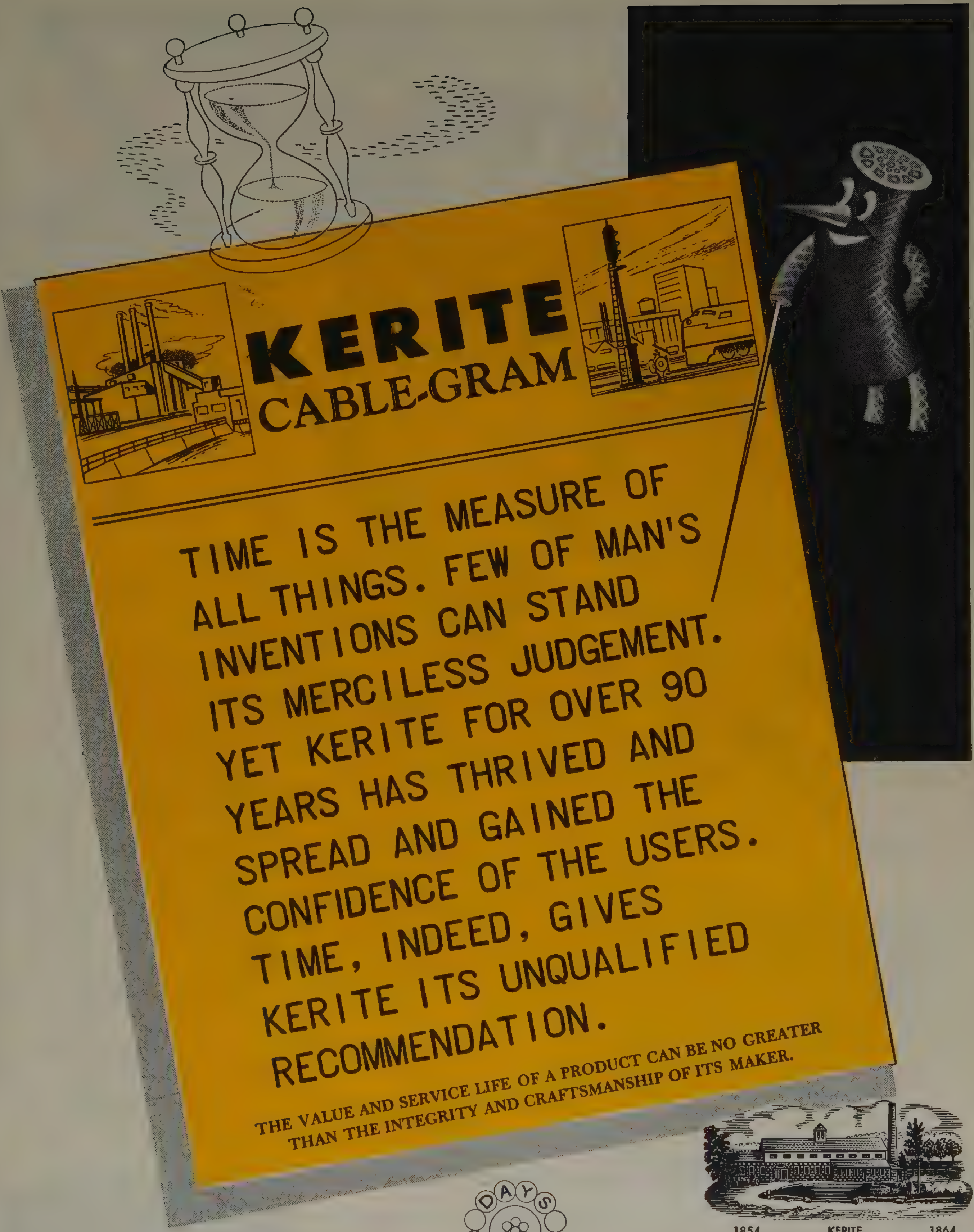
HEWLETT-PACKARD COMPANY

2250 E Page Mill Road — **Palo Alto, California, U. S. A.**

Sales representatives in principal areas.

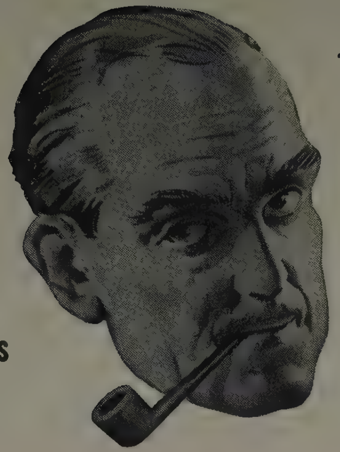
2250

HEWLETT-PACKARD hp INSTRUMENTS



KERITE CABLE

THE KERITE COMPANY—30 Church St., New York 7, N. Y.
Offices also at 122 Michigan Ave., Chicago; 582 Market St., San Francisco; 3901 San Fernando Rd., Glendale 4, Calif.



NO. 4 IN
A SERIES

a transmission line engineer ASKS—

"is there an insulator that will reduce the effects of air pollutions ?"

here is the ANSWER:

Yes, there is. It is the PINCO L-1925 "UNIVERSAL" INSULATOR which is specifically designed to reduce to a minimum, the damaging effects of fly ash and other air-borne industrial wastes which tend to decrease insulator efficiency and create a costly operational maintenance problem.

and 5 reasons WHY . . .

1. Leakage distance of 17" is approximately 50% greater than 10" suspension unit.
2. Outside petticoats shielded above by bell; below by hood.
3. Long, tapered hood is self-cleaning; acts as a splatter-baffle to clean the petticoats.
4. In strings, interior of hood is shielded by unit below—protected against contamination, thus reducing manual cleaning requirements to a minimum.
5. Standard 5¾" spacing permits replacement of conventional 10" suspension units without re-sagging.

Service records over a period of 20 YEARS

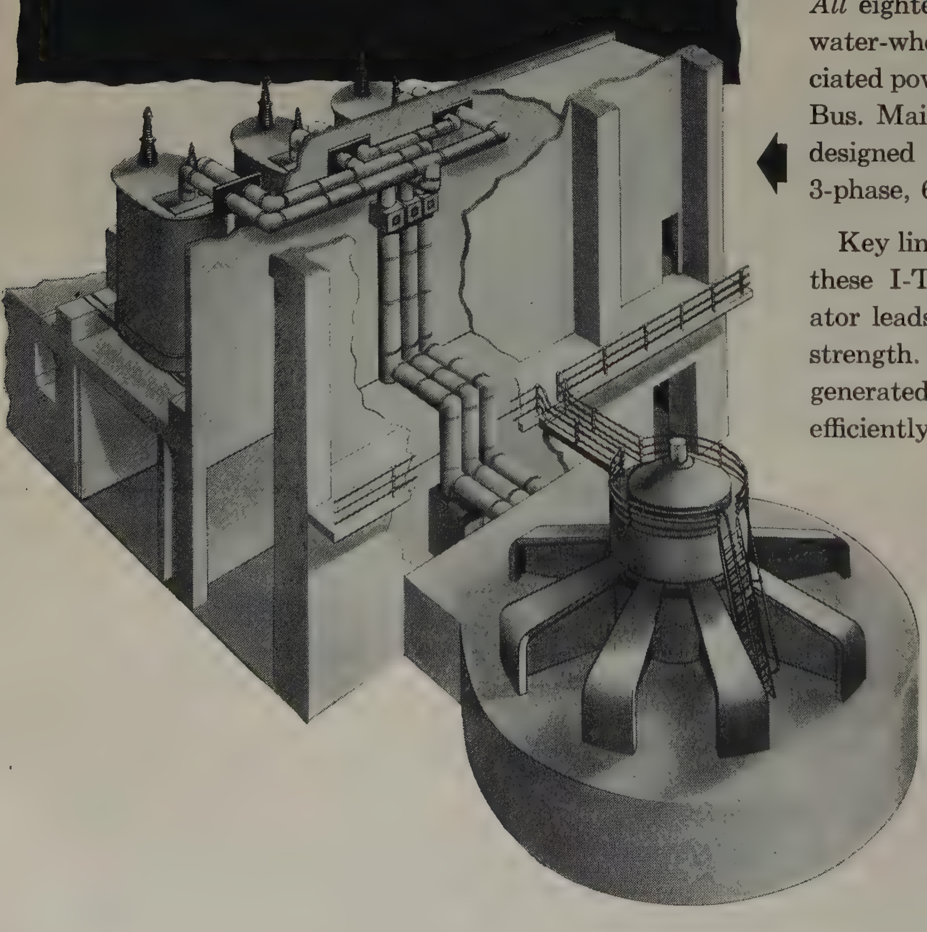
of continuous operation prove that thousands of these Pinco units have met their job requirements 100% in areas where excessive insulator contamination is an operational hazard. Certainly such a record of trouble-free performance proves that they're "right" where it counts . . . right on the job!

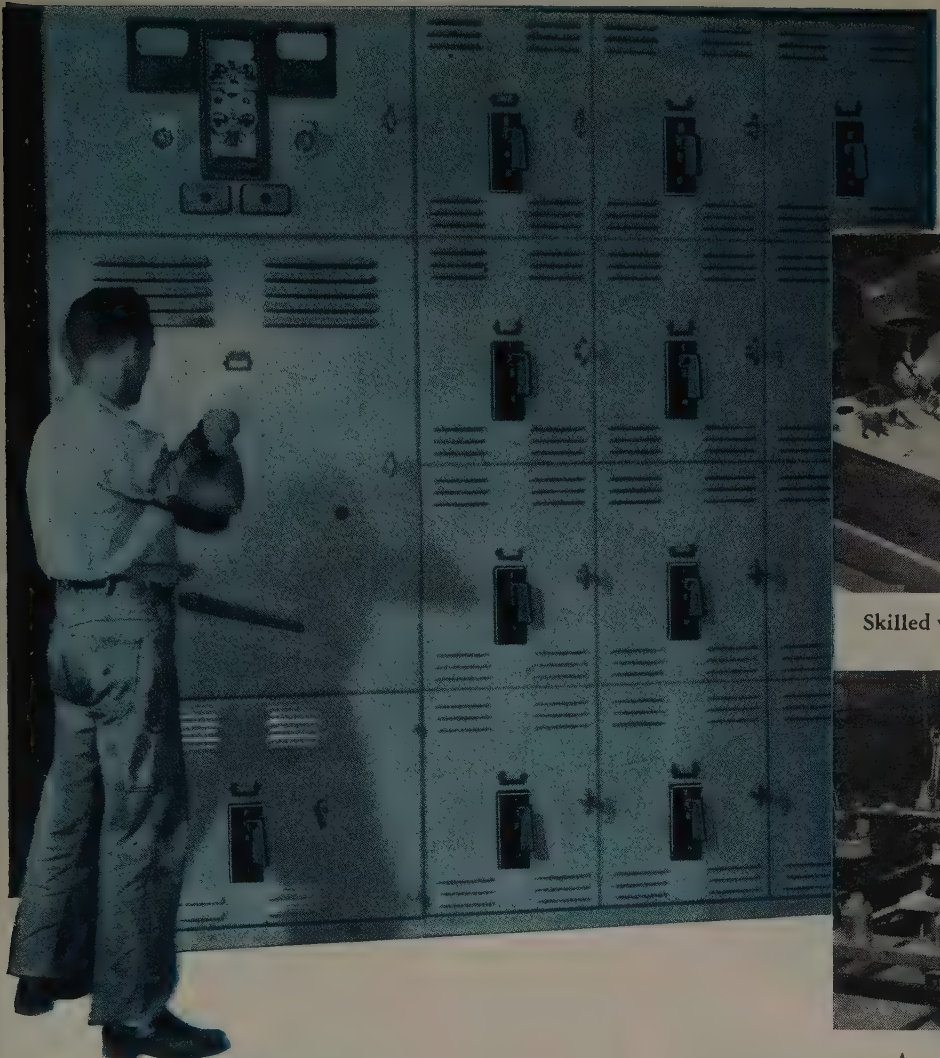
PINCO INSULATORS

RIGHT ON THE JOB—

The Porcelain Insulator Corporation ★ LIMA, NEW YORK

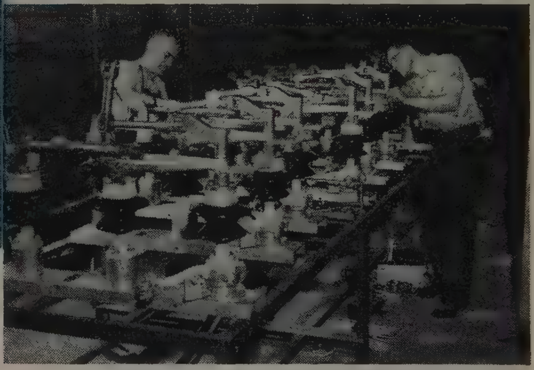
Sales Agents:
Joslyn Mfg. & Supply Co.
Offices in
Principal Cities





Final assembly of custom-built, low voltage, metal-clad switchgear.

Skilled workers assemble precision instruments.



Assembling Duo-Roll air break switches.

Workman wiring large air circuit breaker.

inside story!

Last April we opened an additional plant in Bethlehem, Pennsylvania. It is not only our newest but our largest. Because of this, we've been able to greatly increase our production of the precision-designed, dependable electrical equipment for which Roller-Smith and Elpeco have been noted since the early 1900's. We are happy to be in a position to supply increased amounts of equipment at a time when it is so badly needed and do it in a relatively short time. Despite universal material shortages and our greatly increased production you can be sure, that we . . . on the "inside" . . . are maintaining our same high standard of quality. If you need superior electrical equipment, either for yourself or as part of a defense order, contact us at once. We can't promise everything you might need, but perhaps we can help solve some of your particular problems in a surprisingly short time.

ROLLER SMITH

ELPECO

ROLLER-SMITH CORPORATION
BETHLEHEM, PA.

MANUFACTURERS OF

ROLLER-SMITH Oil and Air Circuit Breakers • High and Low Voltage Switchgear • Unit Substations • Instruments • Precision Balances • Watthour Meters

ELPECO Disconnect Switches • Outdoor Hook Stick Switches • Air Break Switches • Indoor and Outdoor Bus Supports • Bus Ducts • Substations

WHEN YOU REPLACE . . .

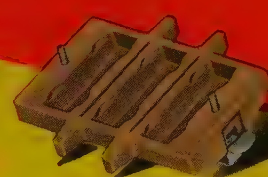
MODERNIZE WITH

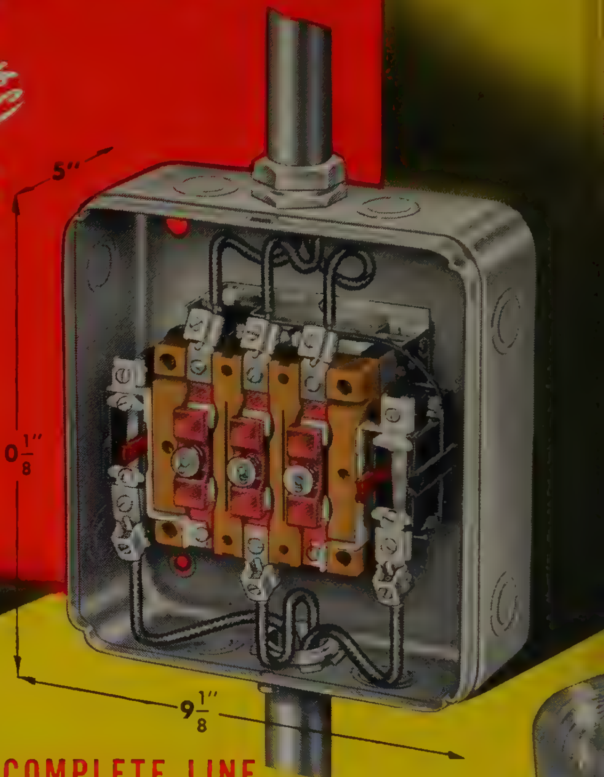
"RIGHT ANGLE" ARROW AH HART ACROSS the LINE

Magnetic MOTOR CONTROLS

Don't replace worn out equipment with obsolete designs. Take advantage of modern-as-tomorrow A-H Motor Controls. Save by lower installation and maintenance costs; profit by added performance. Get ready *TODAY* for tomorrow's increased production requirements.

SIZE 2
ILLUSTRATED





ADVANCED OPERATING MECHANISM

The exclusive Arrow-Hart "RIGHT ANGLE" operating mechanism is the first real advance in starter design since the introduction of the original solenoid type. Size and weight reduced by ½, and operating efficiency and dependability are greatly increased. Replace today with tomorrow's starter, the "RA."

STRAIGHT-THRU WIRING

Here are opportunities for time, work, and space savings up to 30%. Installation time is greatly reduced; maintenance is easier and faster. Arrow-Hart Straight-Thru Wiring is an exclusive, in-built feature, ***NOT*** just a bus-bar arrangement. Only A-H can offer you all these important advantages: safer direct routing with greater separation of line and load; immediate certain identification of circuits; no need for crossing, looping or U-bending; no load terminal on the line side.

A COMPLETE LINE

"RA" Starters are supplied in sizes 0, 1, 2, 3 and 4 with a full range of NEMA enclosures for general service and for hazardous and exposed locations. Other members of the "Right Angle" control line include: "CRA" Contactors in sizes 00, 0, 1, 2, 3 and 4; "RAR" and "RAS", Reversing and Multi-Speed Starters; "RARC" Reversing Contactors; "RAC" Combination Starters; and "RCAR" Combination Reversing Starters.

SEND TODAY FOR LITERATURE COMPLETE WITH RATINGS, DIMENSIONS, WEIGHTS AND ENGINEERING DATA

SPECIFY — ORDER ARROW AH HART **FOR NEW EQUIPMENT FOR REPLACEMENTS**

THE ARROW-HART & HEGEMAN ELECTRIC CO.
HARTFORD 6, CONNECTICUT

Please send me free descriptive literature. I'd like to know more about:

☐ Type "RA" Motor Controls ☐ Type "CRA" Contactors
☐ EXPLO-SAFE, Explosion- and Weatherproof Starters
☐ MULTI-SPEED, REVERSING STARTERS
☐ THE FOLLOWING MOTOR CONTROLS:______________

____

NAME______________________________
POSITION______________________________
CO. NAME______________________________
CO. ADDRESS______________________________
CITY______________ZONE_____STATE__________

ARROW · HART

INDUSTRIAL CONTROL DIVISION

110 Hawthorn St., Hartford 6, Conn., U.S.A.

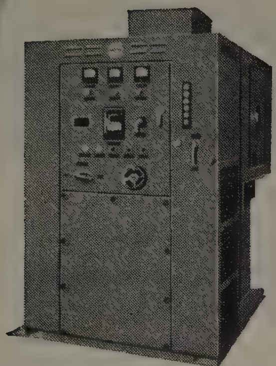
Branches in: ATLANTA, BOSTON, BUFFALO, CHARLOTTE, CHICAGO, CINCINNATI, CLEVELAND, COLUMBUS (O), DALLAS, DENVER, DETROIT, INDIANAPOLIS, KANSAS CITY, LOS ANGELES, MILWAUKEE, MINNEAPOLIS, NEW YORK, PHILADELPHIA, PITTSBURGH, ST. LOUIS, SAN FRANCISCO, SEATTLE, SYRACUSE.

In Canada: ARROW-HART & HEGEMAN (CANADA) LTD., MT. DENNIS, TORONTO 15, ONTARIO.

Printed in U.S.A.

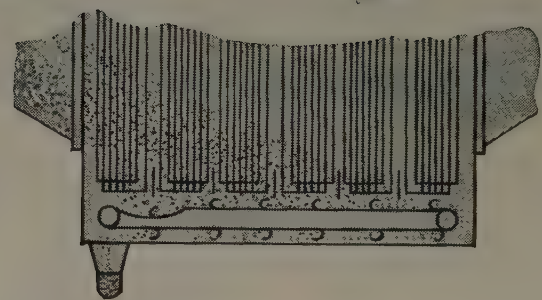
Let's be practical about precipitators

1



This Koppers "packaged" mechanical or vacuum tube power pack is not restricted to an area near the precipitator. It can easily be installed in any convenient place in the plant. Result: Compact designs! More flexibility!

2



This Koppers exclusive—the bottom drag scraper—provides continuous dust removal. Cumbersome hoppers are eliminated and dust handling is simplified. Result: Lower operating costs! Less space requirement!

Here are <u>two</u> <u>ways</u> Koppers engineers <u>simplify</u> <u>precipitator</u> <u>operation</u> <u>for</u> <u>you!</u>

PERFORMANCE GUARANTEED!

Koppers engineers protect your investment in an electrostatic precipitator by guaranteeing both the recovery or gas-cleaning *efficiency* and the *residual content* left in the gas after cleaning. Koppers-Elex electrostatic precipitators are designed, engineered, fabricated, erected and guaranteed *under one contract* by Koppers Company, Inc.

IN ADDITION to high efficiency, Koppers concentrates on the practical aspects of electrostatic precipitator design. Shown above are just two of the many practical features which simplify operation.

Besides these compact power packs and the continuous dust removal features, Koppers-Elex electrostatic precipitators may be of the multiple-chamber type. This means one chamber may be shut down for inspection or maintenance without stopping the gas-cleaning action. The dirty gas is simply diverted through other chambers where cleaning continues.

Because rapping is *sectionalized*, re-entrainment is minimized. And because successive collection fields can be separately *energized*, maximum voltage can be applied to each field—with higher gas-cleaning efficiency resulting. Pressure drops are negligible.

IF YOU HAVE A GAS-CLEANING PROBLEM, write and outline the details for us to review. There is no obligation. Just address your letter to: KOPPERS COMPANY, INC., *Precipitator Dept.*, 236 Scott Street, Baltimore 3, Maryland.

KOPPERS ®

Koppers-Elex ELECTROSTATIC PRECIPITATORS

INSTRUMENTS FOR LABORATORIES

Laboratory Finds Portable Double Bridge Ideal for Transformer Heat-run Tests

0.00004-ohm resistance changes measured with G-E double bridge

The General Electric portable double bridge provides a simple method of measuring the precise resistance values of a transformer's windings during heat-run tests, a large industrial laboratory reported recently.

HIGH ACCURACY

Because of its high accuracy, the bridge has been found ideal for measuring resistance changes in the order of 0.00004 ohms encountered during transformer temperature-run tests. This degree of accuracy is important when making these measurements because the readings are multiplied many times in computing the temperature. Thus, even a minute error greatly affects the calculation.

EASY OPERATION

Designed for easy operation, the G-E portable double bridge has only one dial to adjust while making the measurement. For maximum utility, it has eight ranges that permit measurements extending from 0.0001 to 22 ohms. It is accurate to 0.1 per cent of full-scale value, e.g., 0.000001 ohms at the lowest range.

OWN POWER SOURCE

The bridge saves time in measuring resistance because it contains its own power source and needs only one operator. Its price: only $304.20*. For more information, check coupon for Bulletin GEC-251.

Oscillograph Simplifies Wave Analysis

ON-THE-SPOT TESTS of plant generators are made easily with the G-E Type PM-10 Oscillograph. This multi-element oscillograph quickly determines wave shape; from that, form factor may be calculated and complete wave-analysis charts prepared.

The advantage of the PM-10 in this application is its high-speed. This makes it possible to "draw out" wave shapes so that the ordinates for wave analysis can be more accurately and easily measured.

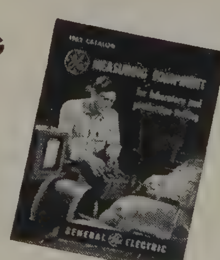
The PM-10 will operate at film speeds up to 1200 feet-per-minute, and it can be equipped with any number of galvanometers up to 12. Additional features include timing lines and simultaneous viewing with recording.

Prices for the PM-10 start at $4000*. For more information check the coupon for Bulletin GEC-449.

1952 CATALOG

G-E Measuring Equipment

80 pages describing all of General Electric's testing and measuring devices. For free copy check GEC-1016 in coupon at right.



G-E Thermocouple Vacuum Gage Aids Metal Evaporation Process

The General Electric Research Laboratory is currently using approximately 200 G-E thermocouple vacuum gages in its research sections. Typical of many of the applications to which these gages have been applied is the one shown above. Dr. L. R. Koller, scientist at the laboratory, is pictured working on a process which evaporates metal coatings onto insulating surfaces.

IMMEDIATE READINGS

Dr. Koller said, "I find this G-E gage entirely satisfactory for this operation. It can be installed in the vacuum system easily and it gives continuous vacuum readings".

LOW COST

The G-E gage provides a convenient means of measuring pressures from 1 to 500 microns. It can be supplied for either glass or metal vacuum systems and is available in either a-c or battery-operated types. Price is $117.58*. Check GEC-385 in coupon below for more information.

*Manufacturers suggested price

SECTION C 605-15, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.

Please send me the following bulletins:
Indicate:
√ for reference only
× for planning an immediate project

- ☐ Thermocouple Vacuum Gage GEC-385
- ☐ Portable Double Bridge GEC-251
- ☐ Type PM-10 Oscillograph GEC-449
- ☐ 1952 Catalog GEC-1016

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COMPANY ....
STREET ....
CITY .... ZONE ...... STATE ....

GENERAL ELECTRIC

PHOTO COURTESY ELECTRIC AUTO-LITE

Hundreds of thousands of feet of Silastic insulated cable are now produced every week by various wire and cable companies. Sizes range from No. 22 to 500,000 circular mils. Applications range from wiring for the new House of Commons to ignition cable for Army ordnance vehicles and Navy control cable.

Silastic insulated wire and cable is in full scale commercial production now because Silastic retains both its physical and its dielectric properties at temperatures ranging from below —70° to over 500°F. Shock and vibration, hot oil, oxidation, corona, outdoor weathering and the mere passage of time have little if any effect on the properties of Silastic. With high thermal conductivity and good dielectric properties over a wide range of frequencies and at both high and low voltages, Silastic is unique among electrical insulating materials for traction motors and Banbury mixer motors as well as wire and cable. And no other resilient gasketing material is serviceable over so wide a temperature span or in contact with oil at such high temperatures.

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For complete information, call our nearest branch office, or

mail this coupon *Today!*

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Dept. No. H-18 Midland, Michigan

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☐ Silastic Facts No. 10 on properties and performance
☐ List of Silastic Fabricators

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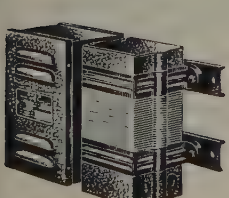
with less than 3% Harmonic Distortion

for Industrial and Defense PROCESS CONTROL, TESTING and RESEARCH

Now all the advantages of static-magnetic voltage regulation are available for harmonic-sensitive applications. All harmonic-neutralized regulators deliver ±1% regulated voltage with commercial sinusoidal output waveshape. They may be used for the most exacting applications in equipment having elements which are sensitive to power frequencies harmonically related to the fundamental. In addition, they have all the characteristics of the standard Sola Type CV static-magnetic regulators: no moving parts . . . no tubes or other expendable components . . . no manual adjustments . . . response 1.5 cycles or less . . . continuous, automatic regulation.

Seven fixed and two variable output models are available from stock.

FIXED OUTPUT, Type CVH



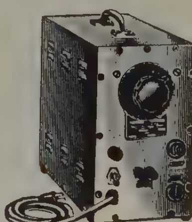
Stock units range in capacities from 30va to 2000va.

Type CVH units are especially suitable for meter calibration or for input to a rectifier when close regulation of the dc output is required. Units of 120va and under have line cord and output receptacle . . . 250va and over have screw type terminals in outlet boxes.

ADJUSTABLE OUTPUT, Type CVL — Solavolt

Two stock units of 250va and 500va are available.

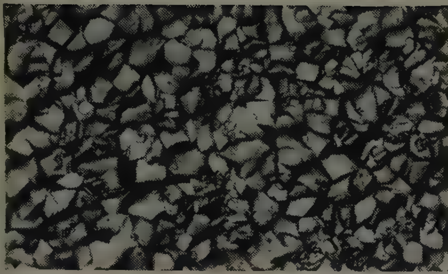
The "Solavolt" will deliver any voltage from 0-130v stabilized within ±1%, and total harmonic distortion less than 3%. Each "Solavolt" is portable for laboratory or shop use. Any or all of their three regulated outputs may be used simultaneously within total maximum rating.



SOLA *Constant Voltage* **TRANSFORMERS**

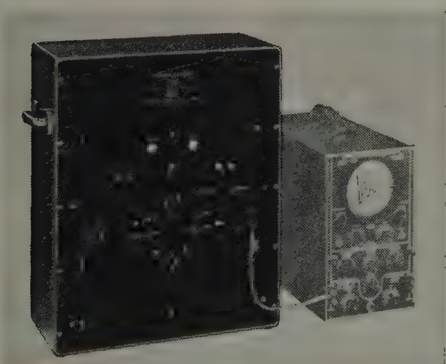
The complete line of Sola Constant Voltage Transformers is described in a 24 page catalog. Write on your letterhead for a copy of A-CV-142.

Manufactured under license by: ADVANCE COMPONENTS LTD., Walthamstow, E., England • M. C. B. & VERITABLE ALTER, Courbevoie (Seine), France
ENDURANCE ELECTRIC CO., Concord West, N. S. W., Australia • UCOA RADIO S.A., Buenos Aires, Argentina



SHOWS SURFACE DETAILS. This Faxfilm® projection of a cylinder bore treated with Lubrite shows crystal size and coverage. Test requires only one minute to make. Special transparent plastic film is pressed against test surface, removed and mounted, then placed in special Faxfilm Projector for magnification of 30 or 100 times. Shows roughness, wear, grain, texture, and finish in minute detail.

CHECKS WELDING TIMING. This Brush Analyzer consisting of a-c amplifier, d-c amplifier and direct-writing oscillograph is used by Taylor-Winfield Corporation to check the current and timing calibration of each spot welder before shipment. By observing wave shapes the inspectors calibrate controls quickly and accurately.



"PLAYS BACK" TRANSIENTS. The Brush Transient Recorder is designed to record and graphically show transient phenomena of 1/5 second or less. This instrument records transients on tape, then reproduces them for visual analysis by an oscilloscope. Signals can be shown complete, or expanded on the screen to show detail. Electrical transients, such as brief spot welder current surges, or other transients which can be converted into electrical impulses can be studied.

For catalog describing these Brush instruments, write The Brush Development Company, Dept. P-30, 3405 Perkins Avenue, Cleveland 14, Ohio.

study dynamic conditions with a BRUSH ANALYZER!

● Testing of parts and structures in actual operation is greatly simplified with the Brush Strain Analyzer.

Here, an engineer studies operating stresses in a diesel engine. Bonded electric strain gages "pick up" the signal, which is then amplified in the Brush Universal Amplifier, and recorded by the Brush Direct-writing Oscillograph. The recorded chart, which is immediately available, eliminates hours of plotting and testing time.

With use of a resistance-sensitive pick-up, the Brush Strain Analyzer provides a complete package unit for obtaining permanent records of torque, strain, vibration, pressure, and other variables.

Use versatile Brush Recording Analyzers to help solve your problems, and save your time. Brush representatives are located throughout the U. S. In Canada: A. C. Wickman, Ltd., P. O. Box 9, Station N, Toronto.

For catalog describing Brush instruments and their applications, write The Brush Development Company, Dept. L-30, 3405 Perkins Ave., Cleveland 14, Ohio.

PUT IT IN WRITING WITH A BRUSH RECORDING ANALYZER..

THE Brush DEVELOPMENT COMPANY

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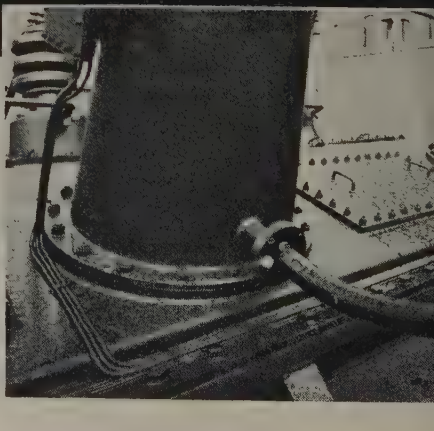
What do you mean, it CAN

Well

SAFETY
MINERAL m.i. INSULATED
WIRING
PYROTENAX ®
A GENERAL CABLE PRODUCT

Safety m.i. Wiring*
in exposed installation
on outdoor
transformer bank.



*Exclusively a General Cable Proc

TAKE ABUSE?

SAFETY m.i. WIRING

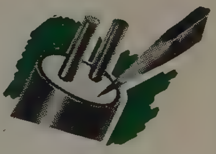
can be hammered, crushed, bent, twisted, jerked —with no impairment of its electrical performance.

Emergency overloads can't hurt it. Age causes no deterioration. It will outlast the structure in which it is installed!

and... ONE STEP INSTALLATION!

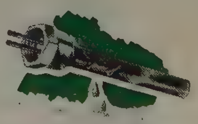
No additional mechanical protection required. Safety m.i. Wiring is its own conduit. Available fittings permit installation in one operation, using standard switch and standard junction boxes. Smaller diameter provides reserve space and assures neat appearance...

and... NO VAPOR PASSAGE!



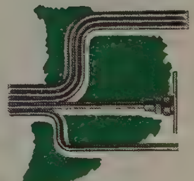
Completely filled with compacted mineral insulation. Necessity for specially installed seals in the cable-run to prevent the passage of combustible gases through a wiring system is wholly unnecessary with Safety m.i. Wiring...

and... COMPLETELY MOISTURE PROOF!



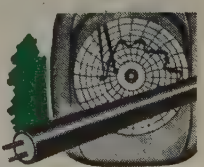
Simple fittings permanently seal both ends of each run of wiring. No possible entrance for moisture. Normal concern over this hazard is thereby completely eliminated...

and... RIGID YET FLEXIBLE!



Thumb-pressure bending, in ordinary sizes, easily fashions orderly wall patterns—conforms wiring to any contour. Once formed, and fastened with standard clamps or straps, it stays put...

and... NO HEAT DETERIORATION!



The mineral insulation is physically stable up to 2800° C., thereby assuring against deterioration by heat, even beyond the melting point (1083° C.) of the copper sheath.

Your General Cable representative is well qualified to discuss the important advantages New Safety m.i. Wiring offers to all industry—for all applications from 0-600 volts. Contact the nearest General Cable office.

GENERAL CABLE
CORPORATION

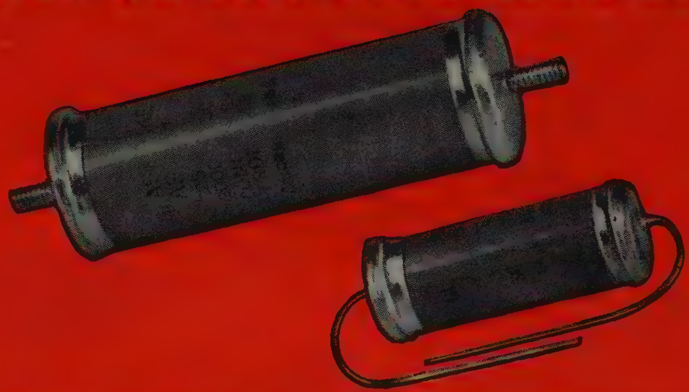
EXECUTIVE OFFICES: 420 LEXINGTON AVENUE, NEW YORK 17, NEW YORK   SALES OFFICES IN PRINCIPAL CITIES OF THE UNITED STATES

"More Power to You"

GLASSMIKES*

the capacitors with the exclusive glass housing and plastic dielectric film

Preferred where High Temperatures, High Resistance, and Low Loss are Essential!



Glassmike capacitors are wound with the plastic film which accentuates the electrical characteristics you require, and results in capacitor design of minimum size. The metal ferrules, soldered to silver bands at each end of the hermetically-sealed glass tubes, eliminate mounting problems.

Applications:

audio and RF coupling
pulse forming and de-spiking networks
radio frequency bypass
low and high pass filter networks
audio frequency coupling
electronic computers
electrometer and oscillator circuits
etc.

Send us your requirements and we will recommend the proper capacitor.

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Plasticon Capacitors
HiVolt Power Supplies
Pulse Forming Networks

Condenser Products Company

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* *Glassmikes* . . . an exclusive capacitor line originally designed by our engineers

ONE TRANSFORMER DESIGN LEADS TO ANOTHER

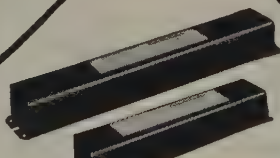
RADIO AND TELEVISION TRANSFORMERS

LUMINOUS TUBE TRANSFORMERS

MANUAL VOLTAGE REGULATORS

OIL BURNER IGNITION TRANSFORMERS

DRY TYPE POWER TRANSFORMERS



FLUORESCENT LAMP BALLASTS

It is often possible to adapt or modify a transformer design to exactly the special electrical and mechanical specifications that may be required for your application.

Illustrated here are a few of the principle lines of transformers we build on which all dies and other production facilities are available. Send your specifications to our Engineering Department.

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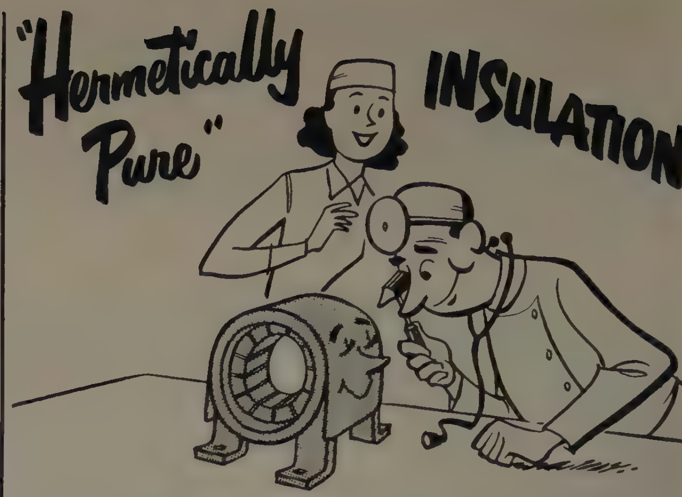
Acme ACME Electric
TRANSFORMERS

"Hermetically Pure" INSULATION



Do you keep your hermetically sealed motors "surgically clean" . . . then ruin a good job by using an inferior quality paper? Too late you'll find an orifice-clogging wax sludge formed in the sealed unit. That's why so many smart winders demand Copaco. Its very low percentage of extractables has nicknamed it "hermetically pure." Only the finest selected raw materials are used.

Write for our new Data Sheet and samples.

Representatives Everywhere

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ELECTRICAL INSULATING PAPER

COTTRELL PAPER COMPANY
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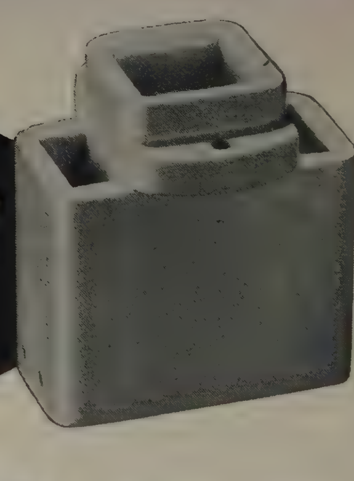
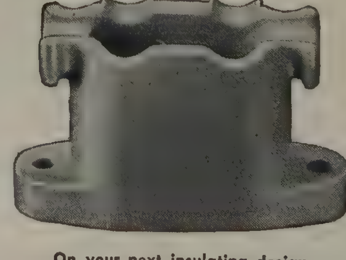
PUT QUALITY FIRST





On your next insulating design problem, put quality *first*, with Universal Porcelain Insulators.

Need a special porcelain insulator? Or a standard unit adapted to your individual needs? Then, put quality first . . . with Universal Porcelain Insulators to meet exact specifications. Universal Insulators are built to withstand thermal shock and physical stress. They give high resistance to temperature changes, moisture, fumes, acids and corrosion.

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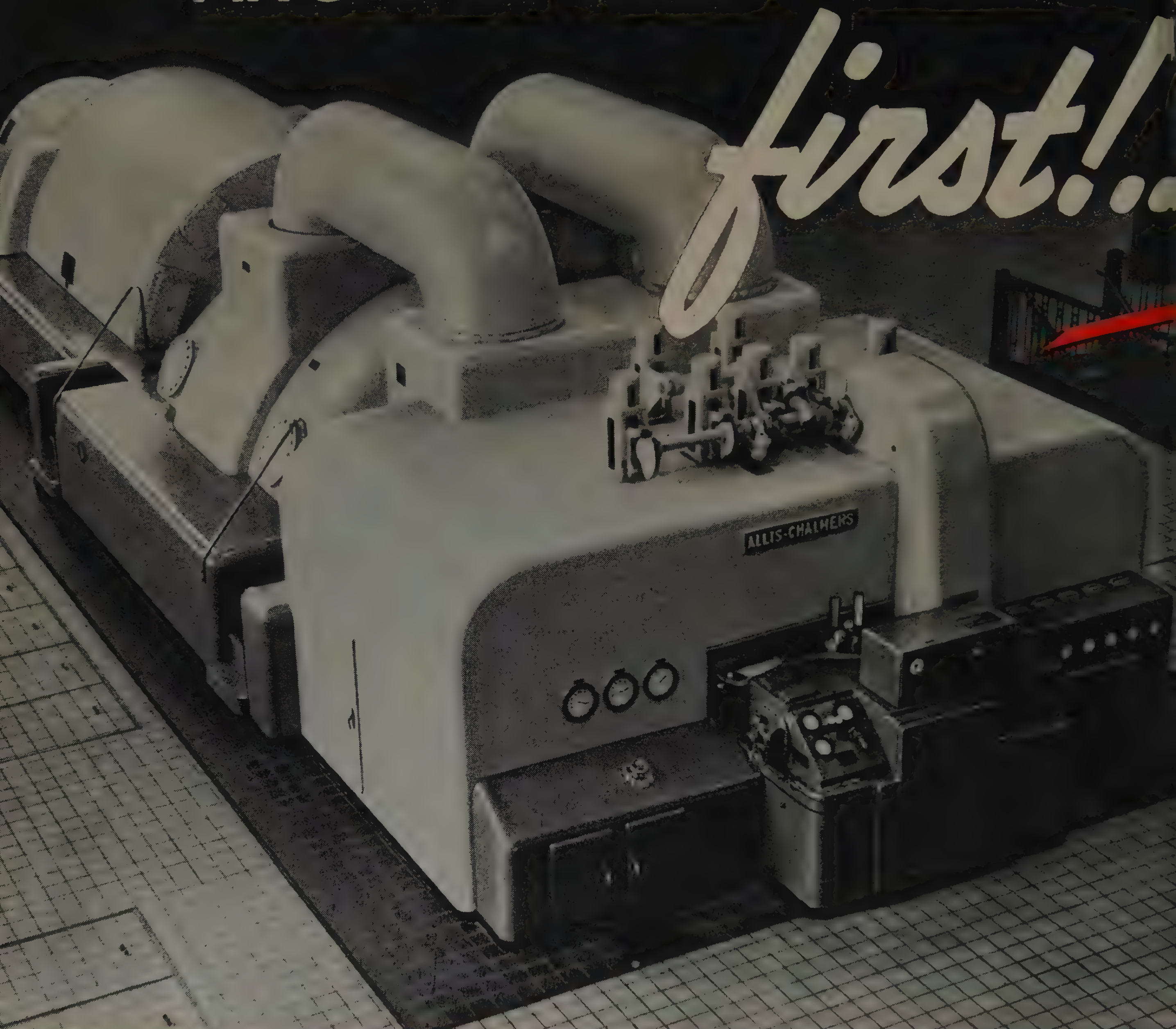


Equipment for Power: Water Conditioning equipment, chemicals and service . . . Steam and Hydraulic Turbines . . . Generators . . . Condensers . . . Steam Jet Air Ejectors . . . Power Plant Pumps and Motors . . . Transformers . . . Circuit Breakers . . . Switchboards and Control . . . Switchgear . . . Unit Substations . . . Utilization equipment.

ALLIS-

IT PAYS TO KEEP PACE WITH MACHINERY PROGRESS

Extend Distribution Regulator Line

Low-cost ⅝% step distribution voltage regulators are now available for every feeder. Additional ratings continue the long line of firsts for the power industry—paced by the introduction of ⅝% step regulators 19 years ago.

Supercharged Cooling

On-the-Line Performance of New-Design Turbine-Generator Proves Worth of Cooling with High-Velocity Hydrogen in Direct Contact with Conductors

IT'S BEEN SAID that good things come in small packages, and here's one that definitely does. Supercharged hydrogen cooling of this turbine-driven generator permitted a reduction in length sufficient to provide numerous design, installation and operating advantages.

Already proved in operation at the Wisconsin Power and Light Company's Edgewater Station, this precedent-setting turbine-generator is to be duplicated in two additional units now on order for the same company.

CHECK THESE ADVANTAGES

In this 60,000-kw, 3600-rpm turbine-generator, a two stage centrifugal compressor integral with the rotor drives hydrogen *through* the rotor conductors at high velocity. This supercharged cooling provides these advantages:

- Generator length reduced—permitting smaller plant size.
- Generator weight cut 25 percent — reducing foundation requirements.
- Subtransient reactance increased — permitting smaller breakers and bus structures, and resulting in lower torques under fault conditions.
- Differential expansion reduced, due to shorter length and greater temperature uniformity.

DISCUSS YOUR NEEDS

Because of pioneering achievements like this, you know that you can rely on Allis-Chalmers for engineering leadership in power production and distribution equipment. And you gain most when you call in your A-C representative during the early planning stages. Allis-Chalmers, Milwaukee 1, Wisconsin. A-3651

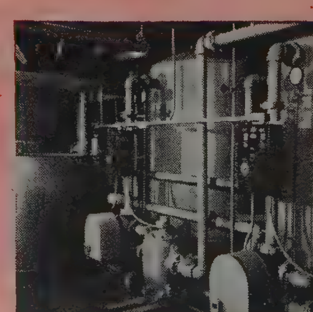
CHALMERS A-C ALLIS-CHALMERS

Built for Outdoor Operation

Condensers and auxiliaries are being built for more and more outdoor central-station installations, and Allis-Chalmers is continually developing improved designs for such money-saving power plant applications.

Add New Ion Exchangers

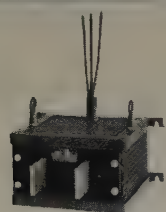
Demineralizers, ion exchangers and water conditioning equipment, chemicals and service of all types — including latest alkalinity-reducing ion exchangers — are available, engineered to fit your requirements.



CALL IN *Standard* TRADE MARK ® TO DESIGN AND BUILD SPECIAL TRANSFORMERS

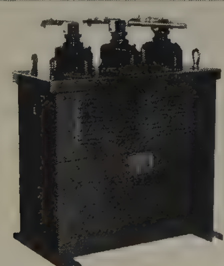
Transformers . . . STANDARD designed and built to fulfill your requirements . . . or constructed to your own specifications.

Years of engineering-manufacturing experience endow The Standard Transformer Company with an understanding of the particular needs of the electrical industry. Custom designed and custom built transformers are a specialty. . . . Need transformer information? There is a STANDARD representative nearby.

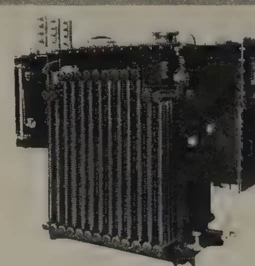


Air cooled, 3 KVA, single-phase, 115 to 2/3 volts.

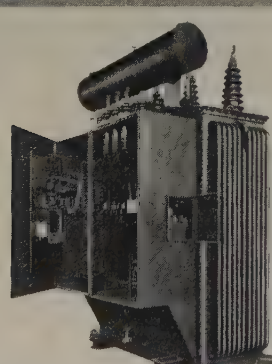
Air cooled, 32 KVA, single-phase, primary voltage 220, secondary voltage 110 to 300 in 10-volt steps.



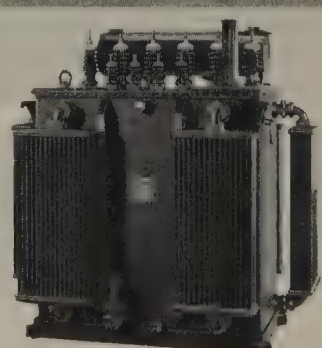
Air cooled, 25 KVA, 3-phase, 2400 to 480 volts.



Askarel cooled, subway type, 500 KVA, 3-phase, 12480 to 216Y/125 volts.



1000 KVA, 3-phase, 66,000 volts primary to 2400/4160Y volts secondary with special accessories.



3000 KVA, 3-phase, 26,000 delta to 2500/4330Y volts. Primary mid-tapped for 13,000 volt autotransformer connection.

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(EXCLUSIVELY TRANSFORMER DESIGNERS AND MANUFACTURERS)

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as a

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A MESSAGE TO YOUNG MEN, TEACHERS AND PARENTS

✦

This pamphlet has been prepared as an educational guide, in order to give something of an introductory insight into the profession of engineering. It is dedicated to the coming generation of engineers and to the constructive contributions which they will make to the life and culture of mankind. Contents of the booklet have been divided into three main parts: The Scope of Engineering; Principal Branches of Engineering; and References to Vocational Guidance Literature.

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MAGNET WIRE

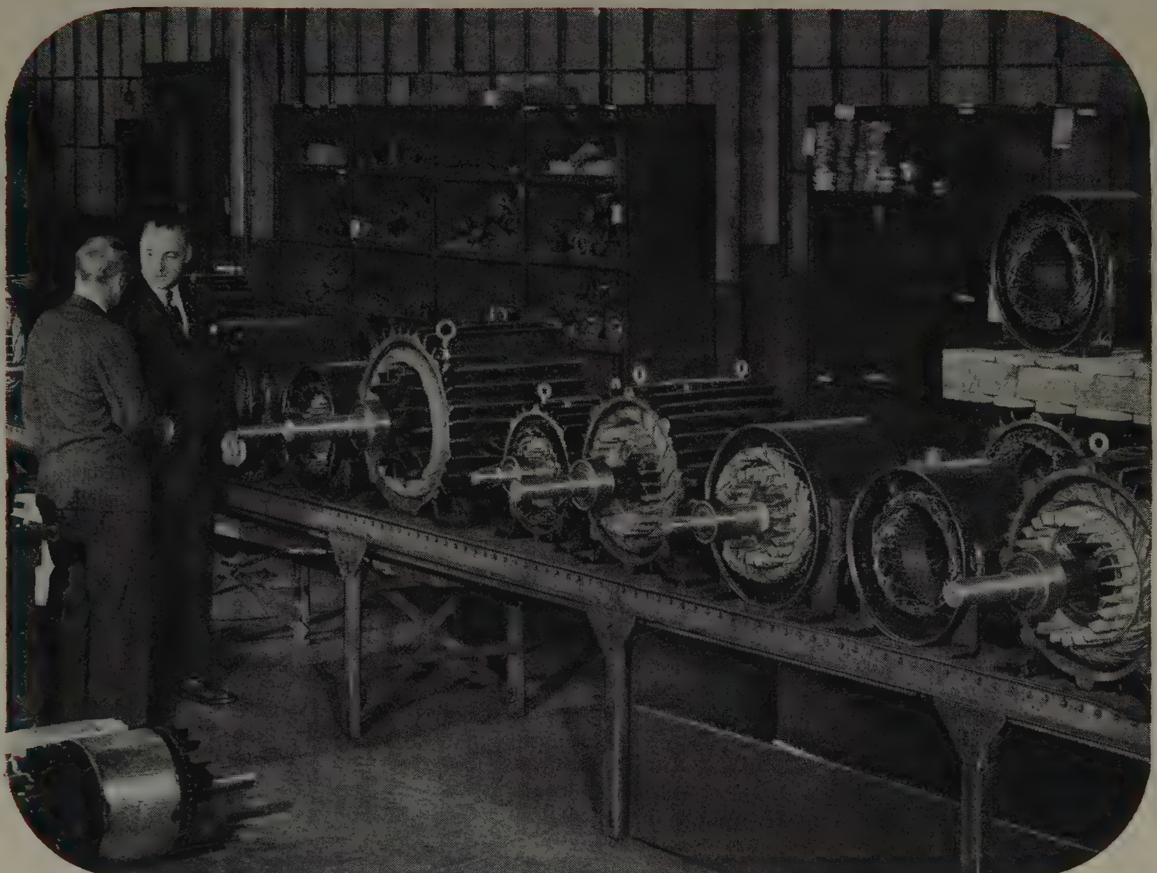

Photo courtesy Crocker-Wheeler Division of the Elliott Company.

Roevar...you can't buy a finer magnet wire

CONTINUAL IMPROVEMENT is a distinguishing feature of Roebling's electrical wire and cable line. And to make Roebling Roevar Magnet Wire today's A-1 specification for high speed winding, we use the toughest insulation we know of.

This Roevar insulation is *many times* more abrasion-resistant than conventional enamels. It is highly resilient . . . bends to a remarkable degree without cracking or coming loose from the conductor. On top of that, it has extra resistance to the solvents that are used in coil-treating varnishes and to all usual baking temperatures.

Roevar Magnet Wire comes in sizes No. 14 to 40 A.W.G. . . . and its small diameter is an important factor in many applications. You can depend on us for the best deliveries possible under today's conditions. John A. Roebling's Sons Company, Trenton 2, N. J.

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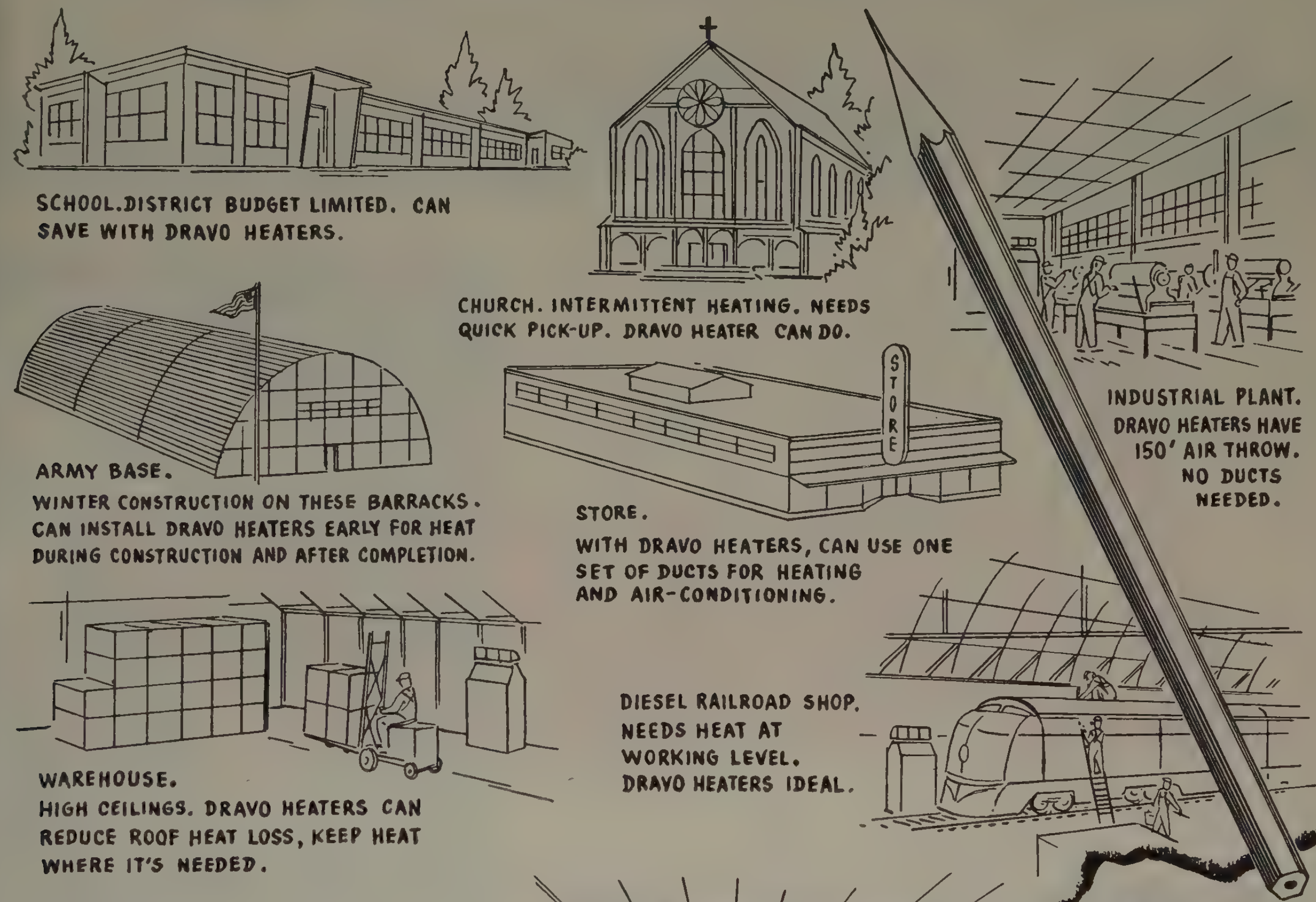
NOTES FROM AN ENGINEER'S SKETCH PAD

LOOKS LIKE THAT VERSATILE DRAVO "COUNTERFLO" HEATER CAN BE USED ON PRACTICALLY ALL OUR JOBS.



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A case study on any ... installations is yours for the asking. For complete information on how Dravo "Counterflo" Heaters can help solve your heating problems, write for Bulletin LM-52 -35

DRAVO CORPORATION

DRAVO

HEATING DEPARTMENT, DRAVO BUILDING, PITTSBURGH 22, PA.

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Announcing

a NEW and SUPERIOR electrical insulation:

ISOMICA

(Trade-mark)

this amazing new material offers you:

- ***higher dielectric strength***
- ***greater uniformity***
- ***better physical characteristics***

ISOMICA MOLDING PLATE: The extremely small size of the mica flakes in Isomica sheets allows smooth right-angle bends without fracturing. Molded shapes made from Isomica plates are free from voids, and free from the concentrations of mica and pockets of binder that have heretofore been a problem in the assembly of Vee rings to commutators and other applications.

Isomica is a built-up electrical insulating material made with thin, coherent, homogeneous, continuous sheets of mica paper (marketed under the trade name Samica), which are coated with organic or inorganic silicone binders, and cured under heat and pressure. The result is *Isomica*.

Isomica is more uniform in weight and thickness than built-up mica made with mica splittings. It has substantially higher minimum dielectric strength, and it does not chip or flake.

Extremely Versatile

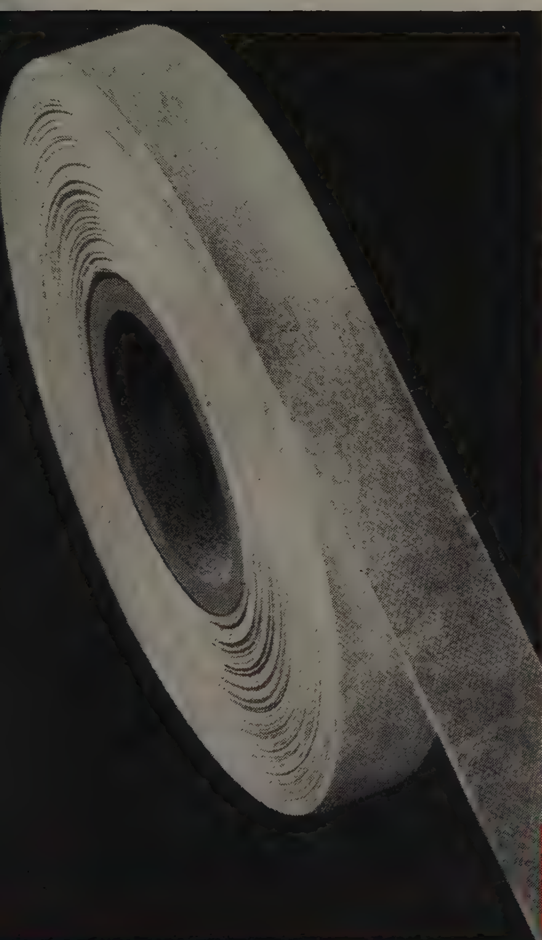
Isomica can be made in the form of sheets, tubes and tapes, as well as formed parts made to your specifications. By modifying the kind and quantity of binder, as well as the degree of cure, it can be produced in various types or grades to meet your specific electrical insulation needs.

Many types of specialty mica insulation which cannot be produced successfully with mica splittings *can* be made with *Isomica*. Most types of built-up mica products now using splittings can be *improved* with *Isomica*.

It may well be the answer to *your* electrical insulation problems. Let us put our 58 years of experience in this field at your service.

Write for Information

Descriptive literature is available, and will be supplied promptly on request. Samples of various types of *Isomica* will be furnished gladly for test purposes. Write us today...on your company letterhead, please.



Applications of Typical Isomica Parts

(In Class H or Class B motors, generators, transformers, etc.)

FLEXIBLE MATERIAL and TAPES

- Slot liner, core and ground insulation.
- Phase to phase insulation.
- Phase and end-winding insulation.
- Primary-secondary separation.
- Coil exteriors and cable splices.
- Coils, cable and cell wrapper tapes.

MOLDED PARTS

- Formed parts of various shapes.
- Commutator Vee rings and cones.
- Slot cells and troughs.
- End-bell insulation.
- Coil forms and spools.
- Tubes of varying cross section for terminals, bars, etc.
- High tension terminals and barriers.
- Angles and bushings.

SEGMENT PLATES

- Variously shaped flat parts subjected to heat and pressure.
- Commutator segments.
- Barriers, washers and discs.

MICO ELECTRICAL INSULATION ®

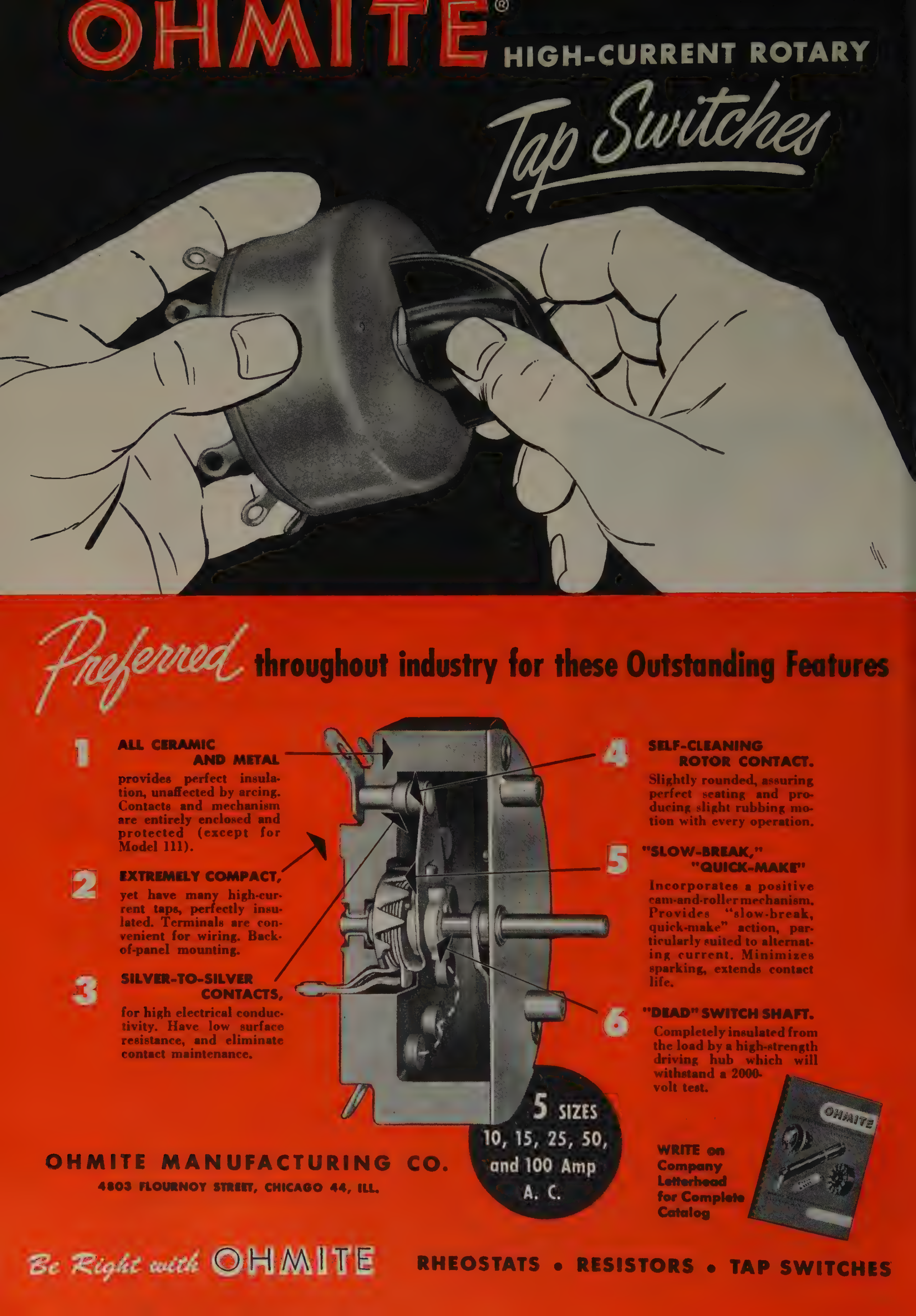
MICA *Insulator* COMPANY

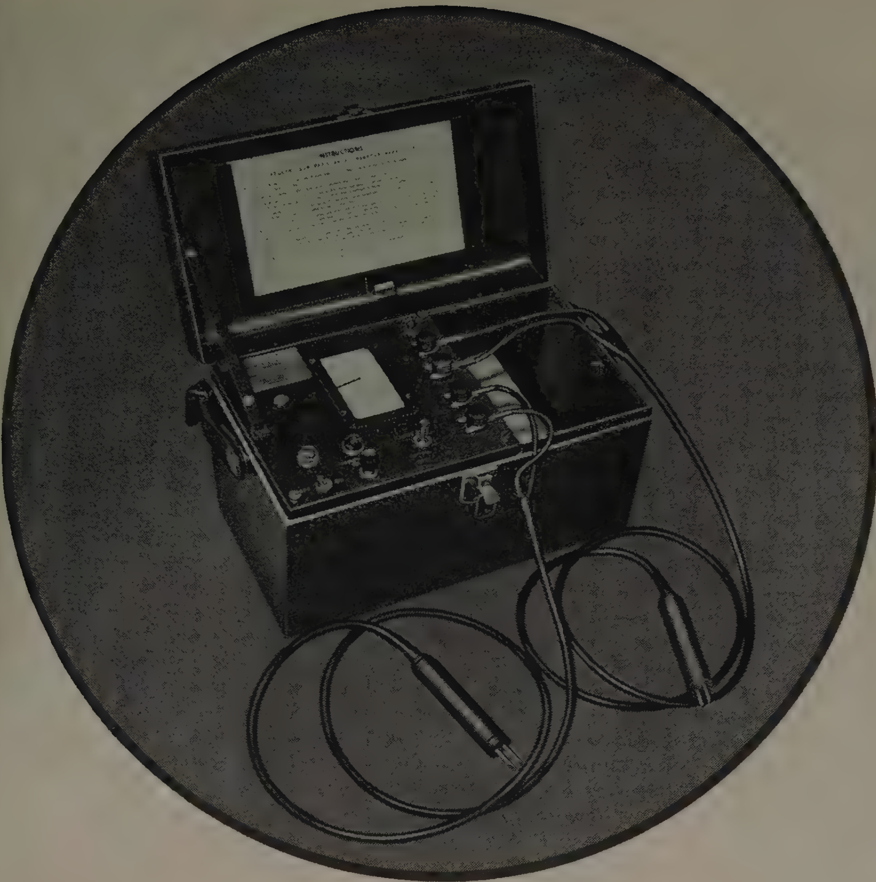
Schenectady 1, New York

Offices in Principal Cities

ISOMICA TAPE: This new Isomica tape can be run on taping machines at high speeds. The tapes have no low spots or voids . . . always show much higher minimum dielectric strength than mica splitting materials of the same thickness.

ISOMICA SEGMENT PLATE: Armature assembly is easier with smooth, uniform, homogeneous Isomica segments. They allow accurate fabrication . . . the danger of sliding of the mica or oozing of the binder during commutator assembly is substantially decreased.


OHMITE®
HIGH-CURRENT ROTARY
Tap Switches
Preferred throughout industry for these Outstanding Features
1 ALL CERAMIC AND METAL
provides perfect insulation, unaffected by arcing. Contacts and mechanism are entirely enclosed and protected (except for Model 111).
2 EXTREMELY COMPACT,
yet have many high-current taps, perfectly insulated. Terminals are convenient for wiring. Back-of-panel mounting.
3 SILVER-TO-SILVER CONTACTS,
for high electrical conductivity. Have low surface resistance, and eliminate contact maintenance.
4 SELF-CLEANING ROTOR CONTACT.
Slightly rounded, assuring perfect seating and producing slight rubbing motion with every operation.
5 "SLOW-BREAK," "QUICK-MAKE"
Incorporates a positive cam-and-roller mechanism. Provides "slow-break, quick-make" action, particularly suited to alternating current. Minimizes sparking, extends contact life.
6 "DEAD" SWITCH SHAFT.
Completely insulated from the load by a high-strength driving hub which will withstand a 2000-volt test.
5 SIZES
10, 15, 25, 50, and 100 Amp
A. C.
OHMITE MANUFACTURING CO.
4803 FLOURNOY STREET, CHICAGO 44, ILL.
WRITE on Company Letterhead for Complete Catalog
OHMITE
Be Right with OHMITE
RHEOSTATS • RESISTORS • TAP SWITCHES



This *NEW INSTRUMENT* Offers Greater Convenience in Field Use

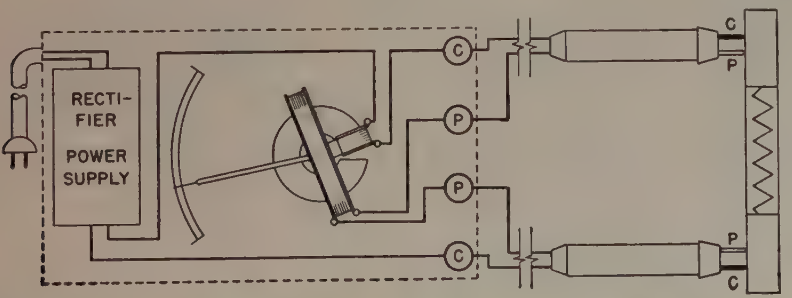
MEGGER® LOW RESISTANCE OHMMETER

This most recent addition to the Megger family of electrical resistance measuring instruments is a general purpose type with self-contained power supply. The set is available in two models, both having the same ranges of 0 to 1000 and 0 to 10,000 microhms. Model 1B carries batteries and Model 1R has a built-in rectifier which plugs into any ordinary lighting circuit outlet. Ample space is provided for the storage of all necessary leads and prods in a compartment of the same case.

The complete unit, with either battery or rectifier weighs only about 19 pounds. It is, therefore, easily portable and convenient to use in the field.

Write for **Bulletin 24-46-EE** which describes these new instruments completely.

Schematic diagram of electrical connections for the Megger Low Resistance Ohmmeter



8819

JAMES G. BIDDLE CO.

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

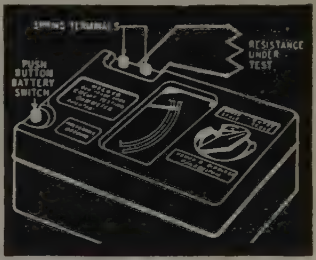
BIDDLE *Instrument News*

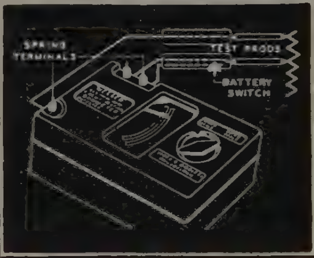
POCKET INSTRUMENT FOR CIRCUIT TESTING

MIDGET MEGGER®
CIRCUIT TESTING OHMMETER
Measures Electrical Resistance
From 0 to 200,000 OHMS

This ideal tool kit or pocket instrument has a direct reading scale with no calculating to do. Operates independently of the exact voltage of the battery that supplies its current. Supplied with selection of double-range scales. Covers extra wide field of miscellaneous measurements of coils, resistors, contacts, windings, circuits, relays, etc.

B Type with battery switch on the instrument.





S Type with battery switch in one of the test prod handles.

A CONVENIENT KIT FOR THE ELECTRICAL MAINTENANCE MAN

If you are concerned with all-around-the-plant electrical tests and resistance measurements, you will find this handy 6 lb. kit indispensable.

In addition to a *Midget Megger Circuit Testing Ohmmeter* as described above, there is a *Midget Megger Insulation Tester* for detecting dirt, moisture, and deterioration in advance of failure, or for trouble shooting on breakdowns. **Bulletin 21-85-EE.**

James G. Biddle Co.
1316 Arch St., Philadelphia 7, Pa.
Gentlemen:
Please send me items checked:
☐ 24-46-EE ☐ 21-85-EE

NAME
JOB FUNCTION
COMPANY
ADDRESS

Specify SQUARE D Motor Starters for 3 Important Reasons

Easy to Wire!

Plenty of wiring space.
Handy solderless terminals.

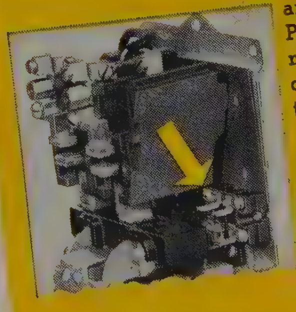
Easy to Get At!

Coils, contacts or overload relays can be changed in no time at all—without disturbing external connections.

Easy to Live With!

Straight line guided motion minimizes wear; large silver alloy contacts insure trouble-free electrical performance.

"Off-the-Shelf" Parts Kits make normal maintenance easier than ever. Each kit contains parts necessary to replace all load contacts and finger springs. An illustrated service bulletin is enclosed to provide quick parts identification and complete installation instructions.



ELECTRICAL INTERLOCKS are available in kit form. Practically any necessary number or arrangement of extra interlock contacts can be added to any standard starter. Sizes 2 and 3 starters will soon have new front-of-panel mounting interlocks for easier installation.
(See cutaway at left)

Write for Bulletin 8536.
Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin.

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

SQUARE D COMPANY

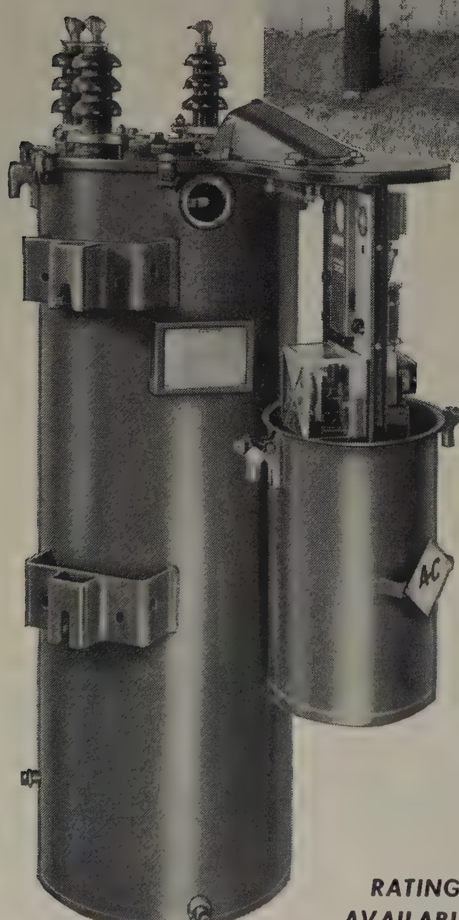
ALLIS-CHALMERS

5/8% STEP VOLTAGE REGULATORS

FIELD TESTED

for Durability!

IN 1944 THESE JFR distribution regulators were installed on a Wisconsin distribution feeder to begin years of tests that proved the value of small regulators.



Eight Years' Operation Prove JFR Distribution Regulator Advantages

FIELD-PROVED voltage regulation for every feeder is available with Allis-Chalmers ⅝% step JFR distribution regulators based on the same principle originally introduced in 1933. Before these regulators were added to the A-C line in 1949, their reliability and accuracy were thoroughly tested and proved in five years of operation on a Wisconsin feeder.

These tests proved that all the advantages of Allis-Chalmers ⅝% step voltage regulation can be brought to distribution feeders economically. Now you can increase revenues on every feeder and improve customer goodwill at the same time!

The low price tag on the Allis-Chalmers distribution regulator plus its low maintenance requirements makes regulation possible where it could never be afforded before. Check these operating features: ± 1 volt band, 20% range, 32 small ⅝% steps, easy control adjustment, long life contacts, unit construction.

Get the complete story. Call your nearest Allis-Chalmers district office or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-3660

RATINGS AVAILABLE

7620 VOLTS — 15-50-100 AMPS
5000 VOLTS — 50-100 AMPS
2500 VOLTS — 100-200 AMPS

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

Originators of ⅝% Step Regulation

NOW—

Keystone ALUMINUM Conductor System for all Applications

A NEW, COMPLETE SYSTEM OFFERING HIGH CURRENT CAPACITY AND LOW IMPEDANCE

Keystone introduces a new development—an aluminum conductor (third rail) system. In addition to conserving critical copper and steel, it offers industrial users many important operating and structural advantages. Here is a complete sliding contact system which is pre-engineered, efficient and compact in design, yet constructed for years of service. It has high current-carrying capacity . . . up to 1,000 amperes . . . with a small cross-sectional area.

Non-magnetic, the new Keystone Aluminum third rail system provides good voltage regulation for alternating current because of its low impedance. It offers new economies because it is easier to install, requires less manpower and eliminates the need for high-cost supporting structures.

It is designed for such applications as main crane runways, bridge conductors, hydro-electric dams and numerous other jobs.

If you have a collector problem or plan a new installation replacement of an old system, consult our engineering specialists.

OPERATIONAL FEATURES

- Requires less space
- Operates under conditions unfavorable to other metals
- Easy maintenance
- Pre-engineered components for easy assembly.

Write today for new, illustrated 4-page folder on Keystone Aluminum Conductor System.

ELECTRIC SERVICE MANUFACTURING CO.

PHILADELPHIA 32, PENNA.

A "NATURAL"

for

ALUMINUM CABLE

If your plans call for the installation of aluminum cables on the basis of copper size, we would like to suggest that you consider the following point. Aluminum will heat to a greater extent than copper when the same amount of current is put through the cable.

So instead of using conventional insulations, which are seldom rated more than 140 F. (60 C.), specify Simplex-Anhydrex XX insulation. This will help overcome the heat problem because Anhydrex XX is rated at 176 F. (80 C.).

Simplex - Anhydrex XX insulation will operate at temperatures up to 176 F. (80 C.) in either wet or dry locations at voltages up to 17,000.

If you must use aluminum because of the copper shortage, let our engineers help you with your problem.

We would be more than happy to give you the latest specification data on Simplex-Anhydrex XX insulation. Simply send your request to the address shown below.

Simplex-Anhydrex XX is a product of Simplex Research.

SIMPLEX-ANHYDREX XX

SIMPLEX WIRE & CABLE CO.
79 Sidney St., Cambridge 39, Mass.

Rome Aluminum Self-Supporting Service Drop Cable is regularly supplied with two RoPrene (Neoprene) insulated power conductors of solid aluminum, spiralled around a bare neutral messenger of ACSR (aluminum conductor steel reinforced). This time-proven construction provides high strength, simplicity of installation.

Rome Aluminum Line Wire is available with covering of RoPrene (Neoprene) or RoLene (polyethylene) as specified. Here is low cost Line Wire having ease of handling, as well as long, non-festooning service life. Uniformly small diameters provide neater appearance, plus reduced wind and ice loading.

It Costs Less to Buy the Best

Rome ALUMINUM

ROME CABLE CORPORATION, ROME, N.Y., AND TORRANCE, CALIF.

CLASSIFIED ADVERTISING

For help and situations wanted, $1.50 per line. Sale and purchase of used machinery, etc., $2.00 per line, minimum 5 lines, maximum 30 lines, not available to dealers. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y., unless other address is given.

Positions Wanted

DESIRE POSITION where both teaching and development work may be carried on. Full time development or teaching positions pertaining to electronic circuits will be considered. Preference given to position where additional graduate work may be taken. B.S. in E.E., B.S. in Mth., 3 years teaching experience in electronics and mth., 1 year electronic circuit development for guided missiles. Reply Box 276.

PATENT DEPARTMENT POSITION with Midwest firm desired by licensed graduate electrical engineer having six years' experience with controls. Expect to receive law degree soon. Write Box 277.

ELECTRICAL ENGINEER, B.S.E.E. 1949. Desires position as Field Service Engineer on industrial equipment and instruments. 2 1/2 years machine shop experience, 3 years electronic design and development work. Age 28, single, free to travel. Prefer Southwest or West Coast. Address Box 278.

SALES ENGINEER, over 20 years' experience, wants Manufacturer's Agency in Virginia and North Carolina for pole-line hardware, transformers, protective equipment, and porcelain insulators and fittings. Wire Box 279.

Positions Open

ENGINEER—Electrical or Mechanical graduate, age 35–45, for design and development work with established midwest manufacturer. Must be capable of complete design and development of relays and light duty oil switches for control of lighting circuits. Excellent opportunity for a man with experience and ability to take complete charge of engineering on a permanent basis. State education, experience, references, and salary desired. Location, Indiana. Address: Box 241.

SOUTHEASTERN UNIVERSITY needs teaching and research personnel in the field of radio and electronics. Salaries will be commensurate with those paid in industry. Graduate assistantships are also available paying $110.00 per month with tuition free. M.S. degree may be earned in one year. Write Box 248.

TRANSFORMER ENGINEER required with minimum ten years' experience in transformer design, preferably including transformer sizes through 10,000 kva, 133 kv. Age preferably between 35 and 45 years. Work will be predominantly supervisory. Salary commensurate with ability. Location Western Pennsylvania. Address: Box 251.

ELECTRICAL ENGINEERS—College graduates, 0–5 years combined industrial and laboratory experience with wire and cable in the conductor and communication fields. ELECTRICAL ENGINEER with strong mathematics background to handle electromagnetic problems involved in aluminum reduction research.

ELECTRONICS ENGINEER—College graduate, 3–5 years' experience in design and development of electronic measuring equipment and control mechanism. Knowledge of communication and transmission systems preferred. Good mathematical background desirable. Apply direct to L. W. Eastwood, Division of Metallurgical Research, Kaiser Aluminum & Chemical Corporation, P. O. Box 1451, Spokane 10, Washington.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY'S DIGITAL COMPUTER LABORATORY needs staff members, with or without experience, for logical design, theoretical analysis, component and circuit research and development (including work on transistors, ferromagnetic and ferroelectric memory cells, magnetic drums, transmission of coded information, and analog-digital conversion). There is also work on use of high-speed digital computers to control large physical systems. This involves study of control requirements of the whole system, reduction of them to a simple pattern of control instructions, and translation of the pattern into computer code. Position requires appreciation for physical systems, ingenuity, and imagination. Training in computer principles provided as necessary. Persons transferring from other fields to acquire experience in digital computers for engineering and military uses are encouraged to apply and may come on leave of absence from their permanent organizations. Position carries opportunity for academic study. Salary appropriate to candidate's experience and training. Reply M.I.T., Cambridge 39, Mass.

WORKS MANAGER, $30,000. Top rate manufacturer of Mechanical and Electrical Products, with 3,000-man plant, seeks an experienced Plant Manager to direct all manufacturing. Age 40 to 50. Reply in confidence to Box 275.

ENGINEER, ELECTRICAL OR MECHANICAL. Unique and interesting permanent job supervising NYC lab engaged in testing and evaluating home appliances. Minimum 10 years' experience, including supervisory experience. Salary open. Send résumé including salary desired. Address Box 274.

ELECTRONIC PACKAGING ENGINEER. M.I.T.'s Digital Computer Laboratory needs a seasoned design engineer with at least five years' experience in design of commercial equipment, preferably associated with electronics. He should have a keen creative mind with an intense interest in designing things that can be made easily on a production basis; a good sense for subassembly construction and compact packaging; a good knowledge of current construction methods; and considerable administrative ability in order to break the job down into small parts for junior people. Opportunity for academic study. Salary appropriate to candidate's experience and training. Reply M.I.T., Cambridge 39, Mass.

NOTE: Closing date for material to be set in the classified advertising column, as well as cancellations for running ads, must be received not later than the first of the month preceding issue; i.e., July first for August issue.

Engineering Societies Personnel Service, Inc.

New York 8 West 40th St. | **Chicago** 84 East Randolph St. | **Detroit** 100 Farnsworth Ave. | **San Francisco** 57 Post St.

In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of these advertisements, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, non-profit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns.

Apply by letter addressed to the key number and mail to New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

Men Available

ELEC ENGR; age 46, married; desires pos chief engr medium size firm mfg motors. Now employed leading elec mfgr as sr designer motors transportation field; 15 yrs exper des, manufacture, test. E-669.

ELEC ENGR, M.S.E.E., M.I.T.; 29, married; Argentine born and presently living in Argentina. Desires to immigrate to the U. S.; 6 yrs. exper with pub util work, incl maint, opern and des; thorough knowl of control boards, relay, and automatic control applications. E-670.

Positions Available

TEACHING PERSONNEL, electrical graduates, with Ph.D. degrees, or New York State Professional Engineering licenses, to teach in the field of electrical machinery and power or in the field of electronics and communications. Rank and salary dependent on qualifications. Location, New York, N. Y. Y-6430.

ELECTRONIC ENGINEER to work in the research and development department and periodically go out with salesmen on field trips. Will devote all of his time to production development of raylon products to be used in the electronics industry. Location, Pennsylvania. Y-6555.

RESEARCH DIRECTOR, electrical graduate, 35–45, good administrator, to take complete charge of basic research and initiate product development for company manufacturing switches, panel boards, and all kinds of secondary electrical distribution equipment. Salary open. Location, Midwest. Y-6593.

RESEARCH ENGINEERS AND TECHNICIANS for research division of university, for research and development work on electronic circuits and systems. Salary open. Location, New York, N. Y. Y-6648.

ASSISTANT CHIEF ENGINEER, under 38, with electrical degree and five to ten years' practical experience in power distribution field, for supervision and administration of engineering department and laboratory; sales engineering—customer help, product applications, product development. Location, South. Y-6657.

SALES ENGINEER, B.S.E.E., with eight to ten years' experience in the following fields desirable: engineering in the electronic field, in the design and application of electronic instruments; technical sales experience with electronic devices. Will call on key customers to determine their needs as regards new test equipment, carry on correspondence with customers, perform some duties concerned with preparation of technical sales information for publication and distribution by the company, assist in connection with technical exhibits and demonstrations. Some traveling. Territories, New York, Long Island, New Jersey, Maryland, Pennsylvania, Washington. Headquarters, New Jersey. Y-6676.

PROGRAM CHIEF, electric motors, graduate electrical engineer or equivalent in experience with studies in electrical engineering subjects, with minimum of ten years' experience in design and development of small a-c and d-c motors, generators, solenoids, electric clutches and brakes as used in the aircraft instrument field. Will take complete charge of motor development laboratory including the performance of engineering design and supervision of personnel involved in drafting and laboratory. Salary, $10,000 a year. Company will pay fee. Location, New York Metropolitan area. Y-6745(b).

SALES ENGINEERS. (a) Electrical Engineer who has had about two years' actual engineering design experience and two to three years' sales experience for company manufacturing electro-mechanical instruments for aircraft guided missiles, etc. Half of work will be in sales; the other half as a project engineer aiding customers with their problems. Salary, about $5000–$7200 a year plus incentive bonus; traveling expenses. (b) Electrical Engineer who has had about five years' actual sales experience for above company. Salary as above. Both positions will require about 50% traveling. Headquarters, New Jersey; territory, eastern United States. Y-6756.

RESEARCH ASSOCIATE, 26–35, with Ph.D. in electrical engineering or physics, to direct activities in field of ionospheric propagation covering range of 2 to 40 megacycles. Salary, $5000–$6000 a year. Location, northern New England. Y-6774.

ELECTRICAL ENGINEERS, graduates, with considerable experience in distribution, to supervise all phases of field operations in construction, maintenance and operations. Salaries open. Location, South America. Y-6789.

ENGINEERS. (a) Senior Electronics Engineer (Research), preferably with MS in EE and five years' experience in electronics for Navy Ordnance. Will design high gain amplifiers, timing circuits, conventional filters, power amplifiers, oscillators, detectors, and special instrumentation. Salary, $4000–$6000 a year. (b) Electronic Development Engineer, preferably with BS in EE or Physics and three or more years' in electronics development, for electronic development, sheet metal layout (drafting, electronic testing, and design). Salary, $3600–$5500 a year. Location, Pennsylvania. Y-6837.

ELECTRICAL ENGINEER, 35–45, with at least ten years' design and construction experience including five years' chemical construction experience. Salary, $8400–$10,200 a year. Location, New York, N. Y. Y-6839(a).

SAFETY AND TRAINING ENGINEER, 30–40, electrical graduate, with considerable experience in public utility safety and job training programs. Some knowledge of Spanish and Portuguese, as considerable traveling in Central and South America is involved. Salary, $5000–$7000 a year. Headquarters, New York, N. Y. Y-6865.

ENGINEERS. (a) Electrical Engineers for electrical control and application work on d-c paper machine drives, a-c finishing machine drives, a-c general equipment drives, general controls, motor generator sets, and industrial lighting. Work experience in the above essential. Salary, $4800–$7200 a year plus all employee benefits. (b) Electrical Engineers for power distribution work in planning and laying out a complete primary and secondary distribution system and helping supervise

the installation. Work experience in above essential. Salary, $4800–$7200 a year plus all employee benefits. Location, Pennsylvania. Y-6870.

ASSISTANT RESEARCH AND DEVELOPMENT ENGINEER, electrical graduate, preferably with some experience in the manufacturing industry, to assist in designing electromagnetic chucks. Some knowledge of mechanical applications advantageous. Location, Rhode Island. Y-6939.

ASSOCIATE PROFESSOR OR FULL PROFESSOR in electrical engineering, Doctor's degree preferred with five years' college teaching experience, to teach advanced electrical engineering subjects in electrical engineering, relative to electronics, advanced circuits, analysis or electrical machinery, power transmission and distribution. Location, Midwest. Y-6946.

INSTRUCTOR OR ASSISTANT PROFESSOR in electrical engineering, to handle all instruction in communication field. Must have advanced degree and preferably industrial experience. Salary open. Location, New England. Y-6950(b).

ELECTRICAL DESIGNER, 25–35, with minimum of two years' experience in electronic circuits, and capable of design work on equipment for manual or automatic operation. Salary, about $6900 a year. Location, upstate New York. Y-6967(a).

INSTRUCTOR OR ASSISTANT PROFESSOR in electrical engineering, with Master's degree, to teach power courses. Position starts September, 1952. Salary, $3600–$3800 for nine months. Location, Ohio. Y-6971.

ELECTRICAL ENGINEERS, 22–25, graduates, with some experience with electrical equipment such as used by heavy industrials in the class of producers of steel, alloys and/or electro-chemicals. Experience with high tension most desirable. Ability to do limited layout and drafting work. Possible knowledge of utility company rates and methods or rate selection and economical operation thereunder by large users of power desirable. Location, New York, N. Y. Y-6993.

INSTRUCTOR in electrical engineering, 25–35, to teach electronics and electronic circuits to junior and senior electrical engineering students, class and laboratory. Salary, about $4000 for nine months. Location, New York Metropolitan area. Y-6999.

SALES ENGINEER, electrical graduate with experience, to sell industrial control, magnetic relays, including hermetically sealed telephone type, fluorescent ballasts, oil burner ignition and neon sign transformers, special magnet coil forms, and similar devices. Straight salary with merit increases. Company car furnished. Location, northern New Jersey. Y-7000.

GENERAL SALES MANAGER, 40–50, with electrical, metallurgical, or chemical degree, for manufacturing company in the field of refractory metals and nonferrous alloys. Should have experience with company manufacturing a wide variety of electrical products, to plan and organize sales, advertising and marketing activities, and other programs. At least fifteen years' practical sales experience in an executive capacity required. Salary, $25,000 a year. Location, Midwest. Y-7001.

ELECTRICAL AND ELECTRONIC DEVELOPMENT ENGINEERS, 20–45, for design of industrial and military electronic equipment for company manufacturing cathode-ray equipment and military electronic equipment. Salary open, depending upon qualifications and experience. Location, New Jersey. Y-7009.

FIELD ENGINEER, recent electrical engineer or physics graduate, for application of electronic instrumentation to research and development problems of government and industrial labs. Salary, $3900–$4500 a year. Location, Washington, D. C., area. Y-7016.

ELECTRICAL ENGINEER with minimum of five years' design and/or manufacturing experience on small motors, generators, and rotary inverters. Duties will consist of design and development work on fractional horsepower motors. Salary, about $6000 a year. Location, Connecticut. Y-7031.

ELECTRICAL DESIGNER, 30–40, with at least four years' experience in power plant design; must be versatile. Knowledge of hydroelectric helpful. Will act as squad leader on electrical work for hydroelectric power plants. Salary, $3.00 per hour. Employer will negotiate fee. Location, Chicago, Ill. R-8767.

GENERAL MANAGER, electrical engineer, to 50, with at least five years' experience in development, engineering, and manufacturing of electronic equipment or parts. Knowledge of electronic manufacturing. Will take full charge of a plant manufacturing electronic equipment. Should be well versed in design, manufacturing, costs, personnel, finance, and sales. Salary, to $15,000 a year. Employer will pay fee. Location, Chicago, Ill. R-8851.

UTILITIES ENGINEER for the layout and revamping of electric, steam, and water distribution systems; develop maps and easement file; plan for expansion. Present system is 3500 IW steam plant at 650#, automatic telephone system and water treating plant. Salary, $8400 a year. Location, Alaska. T-8842.

Want to help build an atomic submarine? . . .
Design an atomic power plant?

START YOUR LIFETIME CAREER IN ATOMIC POWER at Westinghouse

Westinghouse Atomic Power Division has a new plant in the outskirts of Pittsburgh. Laboratories are completely new. Equipment is right up to the minute.

The tools are here to explore atomic energy as a great source of power for transportation and industry. Opportunities for original work are almost without limit.

Westinghouse is now searching for the men who can use these tools and opportunities . . . who want to build a *life career* around atomic power work . . . who want to get in while this great new industry is still on the ground floor.

Here you will work with your kind of people. Every fourth person in the Division is an engineer or scientist. More than half the top Westinghouse executives are engineers. As the exciting new potentials of atomic energy reveal themselves, we expect the men we employ now to provide the nucleus around which this new division will expand.

ATOMIC POWER OPPORTUNITIES ARE WAITING NOW FOR ELECTRICAL ENGINEERS WITH 4 TO 10 YEARS OF THIS KIND OF EXPERIENCE . . .

DESIGN, DEVELOPMENT OR APPLICATION—switchboards, regulators, motor controllers, especially on electrical ship propulsion . . . process regulators, indicators and control devices for liquid level, flow, temperature and pressure . . . servomechanisms, electrical and mechanical system analysis (requires thorough knowledge of electronic controls and simulators and of magnetic amplifiers) . . . power system, apparatus, control equipment and systems.

LIAISON with customers, contractors, designers of component equipment.

SUPERVISION of drafting work.

SALARIES—Open. Westinghouse Atomic Power Division wants good men, and will go out of its way to make attractive offers to good men, based on experience and ability.

LOCATION—Approximately 12 miles south of Pittsburgh. No traffic problems if you live in this general area. Many homes available and under construction. Good shopping in suburban area.

MANY EXTRAS—IN ADDITION TO GOOD PAY! INVESTIGATE!

- Help in finding suitable housing
- We pay interview expenses
- Low cost life, sickness and accident insurance with hospital and surgical benefits
- Modern pension plan
- Opportunity to acquire Westinghouse stock at favorable prices
- Privilege of buying Westinghouse Appliances at discount

HOW TO APPLY—These Westinghouse Atomic Power Division opportunities are not the kind that can be handled in a routine fashion. From the very beginning, you will be in communication with top executives of the Division. Address your application letter to

MR. C. LYNN, Manager of Engineering
Atomic Power Division
WESTINGHOUSE ELECTRIC CORPORATION
P.O. Box 1468
Pittsburgh 30, Pa.

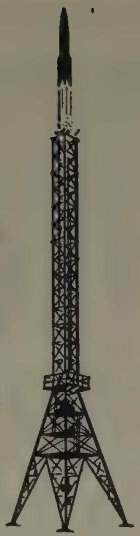
What Mr. Lynn, and other executives who will scrutinize your application want to know is: Where and when you obtained your degree . . . how you did in school . . . where you have worked at your profession . . . what kind of work you have done.

In other words, right now we're more interested in your ability to fill current openings and to develop in the Westinghouse Atomic Power Division than we are in your vital statistics. Write your letter of application accordingly.

You will be in communication with men who are experienced in keeping secrets. All negotiations will be discreet, and *your reply will be kept strictly confidential. Write to Mr. Lynn today.*

AEROPHYSICISTS, DESIGNERS, ENGINEERS—

HERE'S AN EXCITING CHALLENGE



Aerophysics, Electro-Mechanics; Research, Design, Development, Test; The Finest Facilities, Equipment and Materials—all these maintain North American's reputation of keeping "ahead of the industry." You too can be a part of the "North American Challenge" to the future. Write today for information on career opportunities. Please include a summary of your education, background and experience.

Check These North American Extras—

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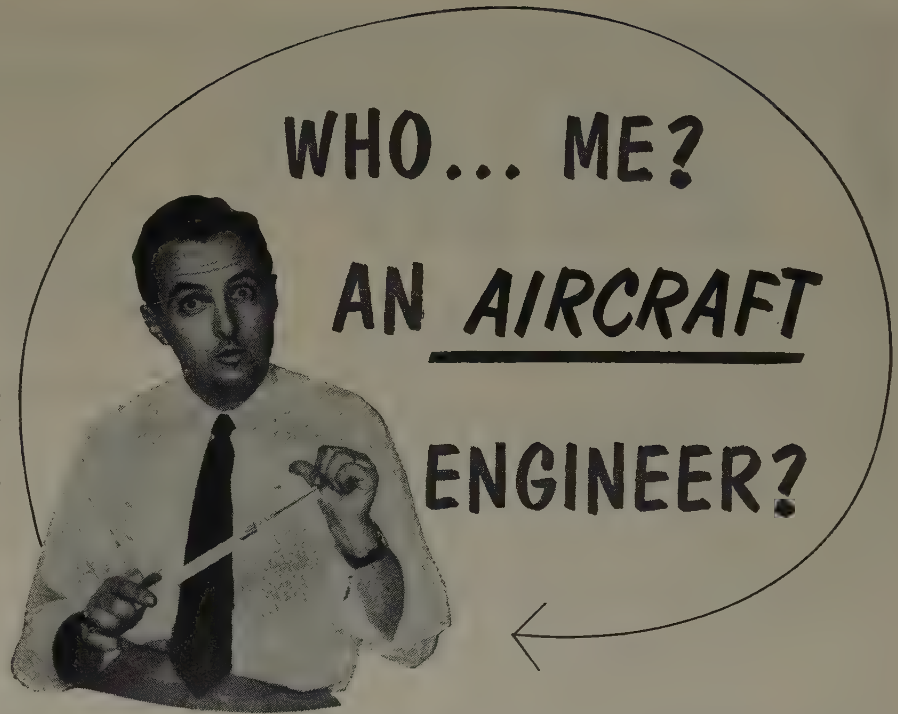

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If smaller, lighter electrical components are needed in the military electronic gear or aircraft controls you are concerned with, investigate the use of CEROC ST, the newest Sprague magnet wire.

Application of a single Teflon overlay to the base ceramic insulation results in a magnet wire which has many of the best properties of both Sprague's CEROC 200 silicone-coated ceramic-insulated wire and CEROC T double-Teflon ceramic-insulated wire.

Complete details of this important new development are given in Engineering Bulletin 404, available on letterhead request.

For latest information on CEROC 200 and CEROC T, write for Bulletins 401-B, 402-H, and 403-C.

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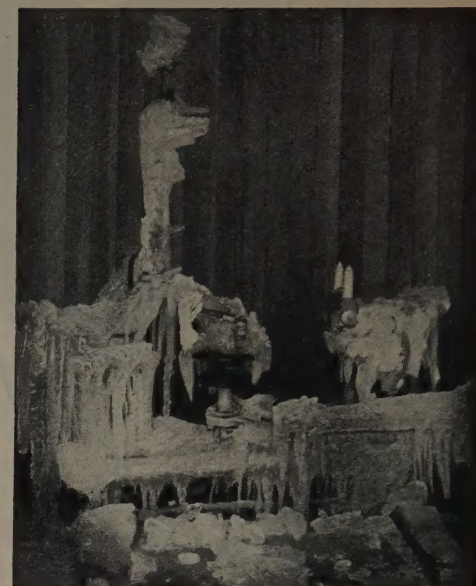
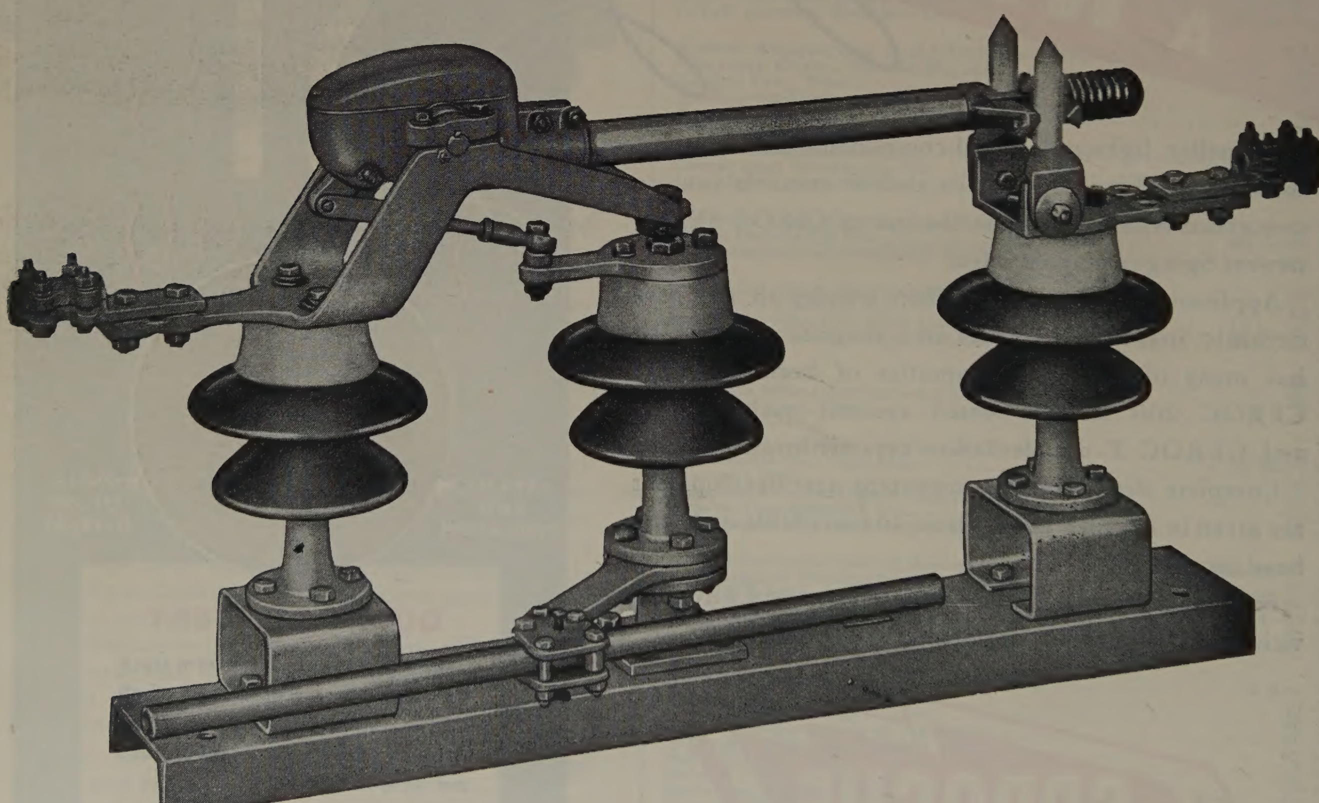
Tests made in our laboratory under severe icing conditions show the switch illustrated below, closed (left) and after opening (right). Ice was over 1" thick: Only 450 inch pounds were required to open switch.





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15,000 Volts, 600 Amperes, Type 0-2
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ACTUAL SIZE

MAXIMUM RATINGS #

Relay and Grid-Controlled Rectifier Service (for anode supply frequency of 60 cps)

PEAK ANODE VOLTAGE:	
Forward	650 max. volts
Inverse	1300 max. volts
GRID-NO. 2 (SHIELD-GRID) VOLTAGE:	
Peak, before anode conduction	−100 max. volts
Average*, during anode conduction	−10 max. volts
GRID-NO. 1 (CONTROL-GRID) VOLTAGE:	
Peak, before anode conduction	−200 max. volts
Average*, during anode conduction	−10 max. volts
CATHODE CURRENT:	
Peak	5 max. amp
Average*	0.5 max. amp
Fault, for duration of 0.1 sec. max.	20 max. amp
GRID-NO. 2 CURRENT:	
Average*	0.05 max. amp
GRID-NO. 1 CURRENT:	
Average*	0.05 max. amp
PEAK HEATER-CATHODE VOLTAGE:	
Heater negative with respect to cathode	100 max. volts
Heater positive with respect to cathode	25 max. volts
AMBIENT TEMPERATURE RANGE	−75 to +90° C
Maximum Circuit Values:	
Grid-No. 1—Circuit Resistance	2 max. megohms

*Averaged over any interval of 30 seconds maximum.
#Absolute values

NOW—precise electronic control at lower cost with the new RCA-6012 gas thyratron

Expressly designed for industrial control applications, the new RCA-6012 gas tetrode features the ruggedness necessary to withstand rough industrial usage. It has the additional advantages of low cost and nationwide renewal distribution...both of importance to the end user.

For motor-control, electronic-inverter, and general relay service at power supply frequencies, the RCA-6012 is rated to withstand a maximum peak inverse anode voltage of 1300 volts, a maximum peak cathode current of 5 amperes, and a maximum average cathode current of 0.5 ampere.

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The RCA-6012 is compactly designed, and employs a structure that increases its resistance to both shock and vibration. A button stem is used to strengthen the mount structure and to provide wide inter-lead spacing as a means of reducing susceptibility to electrolysis and leakage.

For complete technical data on the RCA-6012, write RCA, Commercial Engineering, Section FR39, Harrison, N. J. . . . or contact your nearest RCA field office.

FIELD OFFICES: *(East)* Humboldt 5-3900, 415 S. 5th St., Harrison, N. J. *(Midwest)* Whitehall 4-2900, 589 E. Illinois St., Chicago, Ill. *(West)* Madison 9-3671, 420 S. San Pedro St., Los Angeles, Calif. Tmks. ®

Another new RCA tube

RCA-6080 is a current-regulator tube for use in regulated dc power supplies. Similar to the 6AS7-G, it features a button-stem construction for improved resistance to shock and vibration. The 6082 is a similar tube for aircraft power supplies.

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